BULLETIN No. 4

DEPARTMENT OF THE INTERIOR
THE MINING BUREAU
MANILA

A PRELIMINARY
RECONNOISSANCE OF THE

MANCAYAN-SUYOC MINERAL REGION, LEPANTO, P. I.

BY

A. J. EVELAND

GEOLOGIST, MINING BUREAU

MANILA
BUREAU OF PRINTING
1905

35974

LETTER OF TRANSMITTAL.

THE MINING BUREAU,
Manila, P. I., October 19, 1905.

SIR: I have the honor to transmit herewith, recommending its early publication, the material prepared by Mr. A. J. Eveland, geologist, Mining Bureau, for Bulletin No. 4 of this Bureau, entitled "A Preliminary Reconnoissance of the Mancayan-Suyoc Mineral Region, Lepanto, P. I."

This result of the first field work by Mr. Eveland, in difficult Philippine fields, should be of value to those interested in the mineral resources of these Islands, and, in my opinion, reflects much credit upon Mr. Eveland and the party under his charge.

Very respectfully,

H. D. MCCASKEY,
Chief of the Mining Bureau.

Hon. D. C. WORCESTER,
Secretary of the Interior, Manila.

LETTER OF SUBMITTAL.

THE MINING BUREAU,
Manila, P. I., March 28, 1905.

SIR: I have the honor to submit herewith the manuscript of a preliminary report on the mineral deposits of the Mancayan-Suyoc region of Lepanto Province, Island of Luzon, P. I. It has been prepared for publication as a bulletin of the Mining Bureau.

Very respectfully,

A. J. EVELAND, *Geologist.*

Mr. H. D. MCCASKEY,
Chief of the Mining Bureau, Manila, P. I.

TABLE OF CONTENTS.

A PRELIMINARY RECONNOISSANCE OF THE MANCAYAN-SUYOC MINERAL REGION, LEPANTO, LUZON, P. I.

By Arthur J. Eveland.

Chapter I.

INTRODUCTORY.

FIELD WORK.

The field work upon which is based the following preliminary report on the mineral deposits of the Province of Lepanto, Luzon, P. I., occupied the latter part of the "winter" season of 1903–4, and from early in March to the middle of June. This period of three and one-half months may by no means be taken as the time available in the investigation of the area, as the early advent of the rainy season rendered work impracticable approximately one-half of that period, the daily torrential rains terminating field work with unfailing regularity. In addition to the time spent actually in the field, six weeks were required for transportation to and from Manila, and at the close of the season's work, discontinued when it was absolutely impossible to do more, one section of the party, with the collections and equipment in its care, occupied six weeks in the return to Manila.

Topographic mapping has as yet not been undertaken in the Philippine Islands. Only to a small extent has any primary triangulation work been carried on, and that only on the coasts and harbors, under the United States Coast and Geodetic Survey. The party was therefore organized as completely as possible under the conditions, for varied and general work, and consisted of the writer as geologist and chief, with Mr. H. M. Ickis and Mr. M. Goodman, field assistants, and two rodmen. The absence of one field assistant was unavoidable for over a month, and the connection of one rodman with the party was severed almost immediately upon reaching the field, so that the party practically consisted of the geologist in charge, with one field assistant, one rodman, and such native (Igorot) labor as could be obtained, for the major part of the time.

No detailed investigations, except such as could be profitably carried on with the limited force and time at hand, were contemplated. The region which was to be visited has been long prominent in the infant mineral

industry of the Islands, and only such work that would give a better and fuller knowledge of the mineral resources of the region and an aid to those interested in its development and future progress was undertaken.

For these and other reasons this report is not comparable with more extended and detailed studies, which, it is hoped, are to be undertaken in the near future, but attempts to approach more closely such reconnoissance work as was carried on with wonderful success by the United States Geological Survey in Alaska. Indeed, the conditions of Alaskan work are not greatly dissimilar to the conditions under which all scientific field work is accomplished in the Tropics. The lack of transportation facilities is one of the worst evils to deal with. For every item in the equipment and supplies of use during a more or less extended field trip there is a problem large in its proportions. In the present work the absence of horses or any pack animals thrusts the burdens, literally, on the shoulders of mankind. And the Asiatic races, while much may be said in their favor, do not, as a rule, take kindly to continued labor.

In carrying on geological work one meets with the excessive vegetation of the Tropics, limiting one's vision to a matter of feet, and, in correspondence, the great thickness of soil and decomposed rock material render the solution of even the most simple stratigraphic problem a labor in itself. And considerably not the least in proportions are the climatic conditions which Europeans have to face.

In view of these conditions, therefore, the report submitted is to be understood to be purely preliminary in scope, and the results and deductions based upon it may possibly be subject to future revision and modification when more detailed investigations are carried out.

The actual route, which is indicated in the index map (Pl. I), and means of transportation of the party are briefly as follows: From the map it will be seen that the area indicated lies approximately 160 miles almost due north of Manila. The railroad from Manila north at present only reaches Dagupan, in the Province of Pangasinan. As the most direct means of reaching the territory, then, the party, with its outfit, provisions, and other equipment, was embarked February 24 on the Coast Guard steamer *Masbate* and on February 27 was disembarked at Candon, in the Province of Ilocos Sur.

The trail inland, up the valley of the Balidbid River to Salcedo, north along the western flank of the Cordillera del Teila to Concepcion, then over the Teila Pass to Angaqui, and south to Cervantes, in the valley of the Abra River, presented no other difficulty than lack of transportation. Owing to delays in securing "cargadores" it was not until March 6 that Cervantes, the capital of Lepanto-Bontoc Province, was reached; but finally, on March 11, the first permanent camp of the Mining Bureau party was pitched at Mancayan, the "barrio" or village which was the seat of mining operations of considerable importance in the past.

For two months Mancayan was made the base of operations for that

Photo by A. J. Eveland.

LOOKIN(

Photo by Martin.

TRANSPORTATION METHODS IN LEPANTO.

Photo by A. J. Eveland.

HACIENDA TUBOC.

portion of the mineral region. At the end of about that time camp was shifted to Suyoc, some distance to the south, from which the operations were completed.

It may be well to give a brief résumé of the work done, in order that the understanding may be fully clear.

Of prime importance to any geological work, the topographic base map merits the first consideration. As the relative position of this area could not be determined from any previous maps or data, recourse was had to astronomical methods, and permanent monuments erected on determined points. Checking on these, a base line was laid out, according to the customary procedure, with its conjunctive system of tertiary triangulation over the area. On account of the numerous claims recorded and the evident disposition of the mining fraternity to develop and operate this district, a rather detailed topographic map of a region about 6 miles long and 4 miles wide, on a scale of 400 feet to an inch, was made. It is believed that this map will be of inestimable value to future development work in this district, and therefore more attention was given to it than the general character of the investigation would seem to call for.

The general investigations were conducted along three distinct lines, viz:

(1) A hasty reconnoissance of a large area considerably beyond the immediate vicinity of the "mineral region."

(2) Route surveys, from the coast to the mineral region, by two distinct routes.

(3) A detailed study, as far as the operations permitted, of the ore deposits and geology of the district proper.

In connection, data were recorded for the future more purely geological work in the Islands, the work instituted under the Spanish régime by Abella, Centeno, Santos, Von Drasche, and others, and which will be carried on under American direction and operation.

As stated before, the advent of the rainy season terminated further work in June, and the party returned to Manila. The geologist proceeded overland to the south, through the Province of Benguet, for a hasty reconnoissance of the valley of the Agno River, and to examine the mineral districts of Benguet in order to prepare for the field work in the future, when these areas will be taken up. The mountain trails were followed as far as Baguio, the capital of Benguet, and from there on the route was via the new Government road to Dagupan, where connection with the railroad is made. At the time of the arrival of the geologist in Dagupan railway communication was broken, due to heavy floods, and a steamer was taken to Manila. The entire trip south was made under extremely hard conditions, the floods and storms attendant upon the rainy season being the prominent opposing factor.

The remainder of the party, under charge of Mr. Goodman, field assistant, took the back trail via Angaqui, Concepcion, and Salcedo to

Candon. Boats could not make a landing at that season of the year, neither was it possible, owing to the flooded condition of the coastal plain rivers, to proceed northward to a possible favorable embarking point. In fact, the return from Cervantes to Candon was attended with the utmost danger and hardships at all stages of the route, and that, in addition to bringing safely through the equipment and collections, a detailed route survey was made is greatly to the credit of that portion of the party. It was able to make its way south to San Fernando, thence via steamer to Dagupan, and from there, railway communication having been restored, to Manila. From San Fernando, while awaiting transportation to Manila, a survey was made via Baon, Naguilan, and Sablan, to Baguio, the capital of the Province of Benguet, more or less the central point of the mineral district of that province. By the two route surveys described above the two main lines of communication to the coast from the mineral regions have been accurately mapped for the first time. Comment on the future value of these surveys is unnecessary, and they are included in the text.

The foregoing outline gives briefly the actual movements of the party, in their general relations to the Island of Luzon. Of the difficulties that were met with and overcome, nothing can be written that adequately presents the true conditions. Geological work in the Tropics has for its attendant evils, and to a very small extent, benefits, certain conditions that nothing but actual experience reveals.

ACKNOWLEDGMENTS.

In the course of the field work the Mining Bureau party had reason to be grateful for much assistance in various ways. An attempt is here made to acknowledge these aids and to express the keenest appreciation of the many courtesies which were extended and which in many cases were far beyond the requirements of the official duties of the several gentlemen named. This appreciation is due to Capt. F. F. Stewart, of the Coast Guard steamer *Masbate,* for much information and for assistance in embarking and disembarking the party and equipment; and to Mr. William A. Reed, governor of Lepanto-Bontoc; Messrs. Kane, supervisor, Moir, fiscal, and Travis treasurer, of the same province, for their uniform courtesy and assistance. To Señor D. Martin Mills, for his cordial and unfailing hospitality and much information, and to Señor Don Augusto Fuster, administrador de las Minas de Cobre, Mancayan, for valuable data concerning the past condition of the Mancayan mines. To Messrs. Gaffney and Henry Reeder, who, at the advent of the Mining Bureau party, were the only American miners at that time in the district, the writer is indebted for a great deal of information and aid, most of which, without their guidance, would have been missed. These latter gentlemen gave their services freely as guides in the various

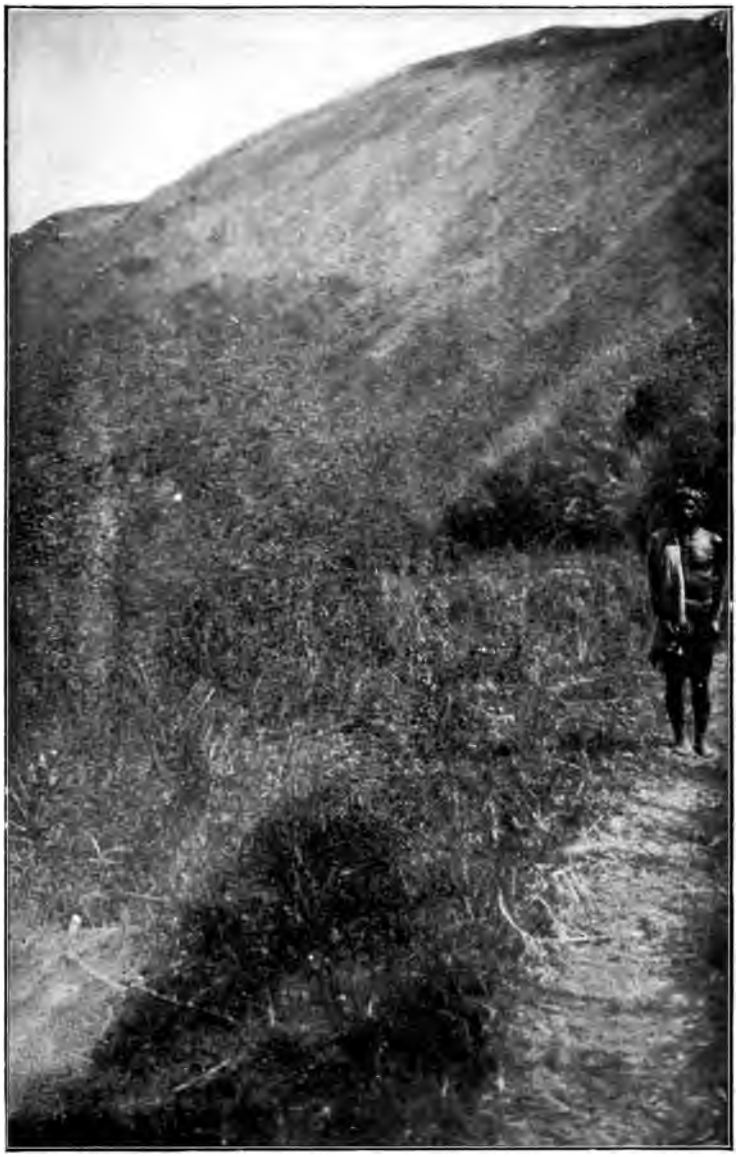


Photo by A. J. Eveland.

ON THE OLD SPANISH ROAD, MANCAYAN.

explorations, during many days. To Mr. William Woodward thanks are due for the use of a substantial house in the latter part of the survey, in the inclement weather; and lastly, but by no means the least, to the many officials, provincial and local, of the regions through which the party passed, and who in every case gave all the assistance in their power.

CHAPTER II.

HISTORY AND PRODUCTION.

The history of the Spanish mining enterprises, whether in the Philippines, South America, or Mexico, is invariably interesting. The story of the mines of Mancayan offers no exception to this, and in view of the present development of the district it is believed it may be of sufficient importance to be given briefly here.

According to the previous writers,[1] the attention of the thinking public of the Philippines and Spain, and especially of those interested in the mining industry, was for a long time drawn to the northern portion of Luzon as a possible source of mineral wealth, as there appeared, and in some abundance, pots and other implements of pure copper which were said to have come from there. Santos in his report[2] says:

> Even in some of the most ancient histories of these Islands (Philippines) copper is cited, among other metals, as one of the products which nature affords with considerable abundance, the natives of the mountains utilizing it for arms, ornaments, and in a profitable business. But the most noteworthy document, which claims attention by its official character and its exactness, as later is verified, is the communication to the governor of his excellency the captain-general, D. Pascual Enrile, of the 20th of June, 1833, in which he states that the utensils that the Igorrotes of the rugged mountain ranges which separate the Province of Cagayan from that of Ilocos make of the copper from the mines have been known for several centuries. * * * With this communication was sent minerals, bars, and spikes of the metal mentioned, which, assayed in the dirección general de minas, gave such good values that not only was it recommended that means be adopted for the exploitation of so much mineral but it gave rise to the creation of the inspection of 1838 and the mining law of 1846.

From such sources as these it became evident that valuable mineral deposits existed, and in 1850 it culminated in the sending of a military expedition into the region to make an investigation, a show of force being essential to Spanish exploration.

With this expedition was sent D. Antonio Hernandez, one of the government engineers, to make an investigation of the deposit, map routes to it, collect specimens, and in general obtain as much information as

---

[1] Hernandez, Antonio: Reconocimiento de un Criadero de Cobre en el Monte Aban, Termino de Mancayan, 1850. Santos, Jose Maria: Informe sobre las Minas de Cobre de las Rancherias de Mancayan, . . . en el Distrito de Lepanto, . . . Filipinas, 1862. Drasche, R. von: Fragmente zu einer Geologie die Insel Luzon (Philippinen), 1878; etc.

[2] Op. cit. Translated by A. J. Eveland.

possible for the public. In this regard it is interesting to note the message of the inspector of mines, Señor Sainz de Baranda. He says:[1]

I believe it is my sacred duty to give you a very special command. The mines are situated at a place very distant from all centers of population and the inhabitants of the country, if not at war with the Christians, are not by any means subjugated, and of a savage and ferocious character. I charge you, therefore, do not expose your life imprudently, or your health, for not only the examination and the mines but all of them and all the savages of Pangasinan and Ilocos combined are not worth the life of a Spaniard, and least of all of an engineer of your merits and circumstances.

Hernandez left Manila February 3, 1850, and proceeded to Mancayan via the east coast of Luzon to San Fernando, thence overland to the mines, returning about a month later, having spent seventeen days in mountain travel. His description,[2] preceded by the general narrative of the expedition, is as follows:

Marching from Sugud to the north-northwest to find the valley of the Abra, there is found, after three hours of travel in the territory of Mancayan in the immediate vicinity of the rancherias of Pacpac and Tavio, a deep glen where runs the Arroyo Tavio or Magamban. This glen is bounded on the north by the mountain Aban, on the south by the Sapit, and on the east by the Tavio, more extensive and elevated than the other two. In the southern side of the first is presented a cut or face of 60 or 70 feet in height and 190 or 200 varas (600 or 650 feet) in length, caused by the landslides which have been produced by past excavations in the middle of the declivity, and the constant action of the atmospheric agents, showing in places a considerable mass of compact quartz with pyrite of iron, whose limits can not be figured, because it is seen to be covered by soil, not presenting apparent stratification, but broken and full of fissures on all the surface; some parts are filled with decomposed quartzose or earthy substances stained generally by oxides of iron or carbonate of copper, and others, although in lesser number, hung with small crystals generally of barite.

The quartz carries in some places gray copper, now intimately disseminated in the mass of the rock in the same manner as is the pyrite of iron, again in small veins from two to three fingers in length, and finally in irregular cavities and in pockets of no great extension. Sometimes the mineral is found compact with the quartz without any appearance of continuity; at others filling more or less completely the crevices of the rocks, leaving several fissures or species of geodes with marked crystallization; and in others finally, and this happens in preference in the masses of larger size, it is found separated from the quartz by well-marked bands of gouge or selvage, of a species of fine clay and of great whiteness, although frequently stained by the green carbonate of copper.

Over the larger concentration of gray copper which is presented to view there has been opened a species of irregular excavation of some 4 varas (13 feet) in depth, and in one of the sides is found a face of the mineral 7 feet in width and 10 in height, terminating in the foreground in selvage and empacked in a tereno summarily weak and decomposed. This being under the surface covered by rocks and fragments of quartz, it is impossible to see where or in what form it is extended; in a like manner the cut of the excavation does not permit of judging

[1] Translated by A. J. Eveland.

[2] Translated by H. D. McCaskey, Chief of the Mining Bureau.

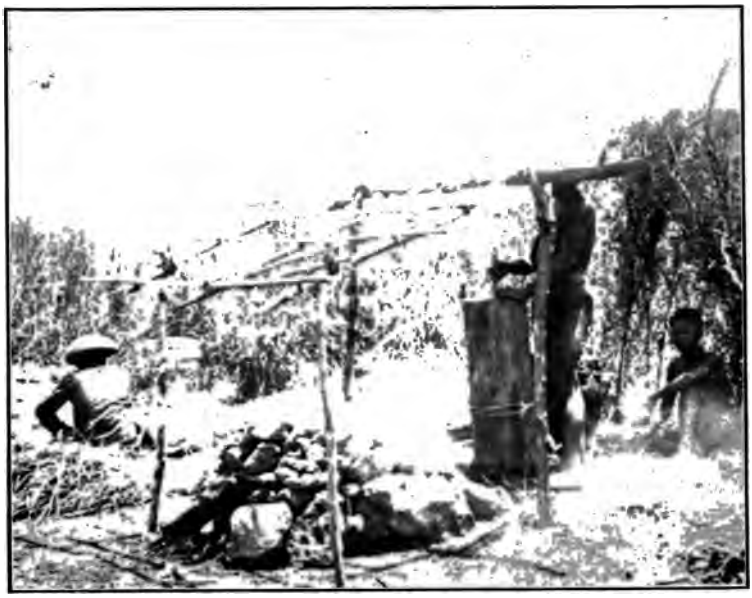
(*a*) First roasting.

Photos by A. J. Eveland.

(*b*) Completion of roast.

IGOROT COPPER SMELTING.

(*a*) Clearing the matte.



Photos by A. J. Eveland.

(*b*) Roasting the matte.

IGOROT COPPER SMELTING.

as to the extent of the deposit either in length or depth, seeing only that it continues to the interior of the mountain and to the bottom of the work.

The mineral pertains to the kind called "tenantite" (tedrahedrite?) or arsenical gray copper, being a sulphide of copper, arsenic, and iron, and containing above 44 per cent of copper, 29 of sulphur, 18 of arsenic, and 9 of iron, and not including the silica, which is found mechanically mixed and therefore in variable quantities. This species, which is that which constitutes the deposit, is found in a mass, somewhat crystallized, and with the crystals there are found, although in small quantities, small portions of pyrite of copper, anhydrous crusts of silica, tablets of barite covered by crystallized quartz, and some pyrite of iron. The matrix is compact quartz with some barite, and many specimens offer the aspect of a breccia of quartz with cement of gray copper.

The works, which consist only of holes or small caves of few varas in extension, are found scattered over a distance of approximately 180 varas (600 feet). And judging by the considerable quantity of wash which covers the ground to the arroyo, and the cut which is seen in the side of the mountain, attended on the other hand by little present activity of works, it is to be presumed that the exploitation of this deposit dates back to a very ancient period. In the beginning they probably worked on top of the site where they are now working, and by degrees, after having exhausted the mineral immediately under the surface, have gone lower toward the arroyo, thereby precipitating, little by little, through lack of system, a considerable mass of rock, which has removed a large part of the ancient works; nevertheless, there are yet preserved parts of it of greater extent than those which are now worked.

To open a work the Igorots commence to collect water in a kind of pool or basin which they have formed on top of the declivity, letting it out through one opening, thus causing to fall with considerable violence a mass of water, uncovering the mineral, and indicating the more appropriate places for exploitation. The excavations are executed by means of fire. Placing a little wood fastened to the wall, they ignite it and the following day the mass is found split, which they easily separate from the copper by crushing with stones.

Although the mass of the deposit is a compact quartz very consistent, it is full of fissures, which makes it necessary to support it, and for this they employ small logs of pine which they place in irregular numbers at the places threatening ruin; notwithstanding this, there is no mine which offers even half a security, and several mishaps caused by cavings have already occurred.

TREATMENT OF THE ORE.

The mineral after being extracted from the mine is submitted first to a roasting, or, better yet, a crude melting; for this the natives open in the ground a hole one cuarta in diameter by two or three fingers deep, which they cover with some thin sticks forming a gridiron, above which they place a small, compact heap of mineral, held down by a board or piece of tree; and they cover all with thin pine wood, leaving a protected hollow above the board. They ignite this at once, leaving it alone until it has consumed the wood and completely heated the sulphur of the mineral, which takes two or three hours. The products are an impure mass of copper mixed with earthen substances and pieces of coal and scorias of quartz which offer the aspect of a breccia in which the cement has partly disappeared, converting it into a porous mass.

The copper matte then suffers a melting process for black copper, which they execute in the following manner: They make a hole six or eight fingers in diameter which they surround with stones forming a species of hearth or crucible,

leaving an open space for the placing of a pipe connecting with a cylinder bellows. This consists of two cylinders made from a hollowed trunk of pine in which run pistons formed by blocks of wood dressed on their circumferences with dry herbs and chicken feathers, which are held down only by the bellows, so they work in the manner of springs against the interior surface of the cylinders. In the lower part there is a hole and in that they place a cane, closing the valve at the beginning of the stroke.

Having formed the oven in this manner they charge it with pine fuel, mixed copper and matte, and put the bellows in motion, taking care to add the fuel in proportion to its consumption, and to agitate little by little with a cane so the copper may fall to the bottom and be cleaned from the foreign substances with which it may be mixed. When they know that the copper has all united into one mass, which should take place after ten or fifteen minutes, they stop the bellows and take out the coal and scorias which overfloat the metallic bath, leaving it uncovered until it has hardened a little and acquired sufficient consistency so that it may be handled. The product is a cake of black copper of rough and broken surface full of earth and pieces of fuel.

This cake they place at once on a bonfire, where they leave it two or three hours, making it suffer a kind of roasting process which purifies it somewhat, and they afterwards melt it in the same furnace, placing it in a species of crucible or mold of refractory clay. At the end of this they put the crucible in the hole and over it they place the stone cover and surround it with fuel. They then force a blast, and after the copper is melted they uncover the bath, taking out all the impurities. They remove the crucible from the furnace, and later, when the mass has commenced to consolidate, they compress it with a stick. Finally they take the cake from the crucible, bury it in ashes until it has cooled, and smooth its surface a little by striking it with a stone.

The copper obtained in this manner they sell partly in cakes to the Christian people in the lowlands, and partly dedicate to the manufacture of pots and boilers which the Igorots forge with stones; also making of the same metal bars, tongs, and small pipes for smoking.

There remains now to consider the deposit of copper of Mancayan from an industrial point of view. According to what we have already said, the operations practiced up to date are all very superficial, and we do not believe they authorize the fixing of an opinion with respect to their importance. We are only able to say that the copper deposits pertain to the class of irregular deposits, and that, like the study of the laws which follow the distribution of the mineral, they demand a more mature examination and other methods of observation than the very limited ones which we have been able to make. Interesting above all is the inquiry as to whether the mineral penetrates to the interior of the mountain Aban, and whether the discovered masses in its declivities are only indications of concentrates of greater importance; and we believe that that already discovered is sufficient to justify a determination of this point. For this purpose there could be opened a gallery toward the interior of the mountain which could follow the direction of some of the masses to-day in exploitation, and afterwards there could be opened other galleries branching from the first in a perpendicular direction.

Furthermore, this deposit, by reason of its very irregularity, offers itself better to a system of irregular exploitation than to an arranged plan of operations. To undertake this there must first be expenses of some consideration in preparatory work, which besides their costliness will have to be of slow execution owing to the hardness of the rock. Nor should there be disregarded the topographical position of the territory of Mancayan, and the primitive state of its inhabitants.

Photo by A. J. Eveland.

SMELTER SITE, CANTABRO-FILIPINO COMPANY, MANCAYAN.

The report of Hernandez seems to have awakened considerable interest in public opinion, and the Government took steps to improve the output and methods of mining, requesting information from the engineer. The latter recommended several small improvements, and, with the caustic comment from his chief, that "all the instructions and regulations that could be given are utterly useless as being beyond the knowledge and intelligence of the Igorots, and even beyond that of the persons who have requested that they be communicated to the Igorots," Herandez's connection with the mines ceased.

From the date of this report (1850) several years elapsed before the copper district was brought before the public. Then, in 1856, Señor T. Balbas y Castro, made application for the demarcation of the properties. He presents an agreement[1] made in March, 1865, with—

> The infidels, Tibaldo, gobernadorcillo of the rancheria of Mancayan; Mendoza, principal man of the rancheria of Tubo; Lancungan, principal man of the rancheria of Balili; Bayaque, of Bata; Tambana, of Bulalacao; Paduan, of Talbac; and Bagnaqan, of Pat Pat (and others), * * * who, of their own free will and accord, without the mediation of either physical or moral compulsion, deception, or fraud, but because they are persuaded of the advantages that are to be attained; after having conference with their subjects, and in conformity with these, they have agreed in abandoning * * * the right they may have to the mountains which form the fissure through which runs the small river of Magamba, which washes the entire deposit of the metal, * * * with the condition that these shall be respected and no work done in the interior of the small caves or mines which each rancheria has in exploitation from time immemorial.

For this concession was paid the sum of 500 pesos (about $200) and the natives were guaranteed employment in the mines at regular fixed rates. This agreement was approved by the Government and a stock company was formed under the leadership of Señor Balbas, which proceeded to open the mines, two pertenencias of 83,000 square meters each, under the Spanish law, being laid out, and preliminary work being commenced in the same year.

PRODUCTION.

While but few figures of the production of these workings are available, those at hand may be worthy of record, and are here given:

Before the Cantabro-Filipino Company took hold of these workings, it is estimated[2] that from 1840 to 1855, during fifteen years, 40,250 pounds of copper were produced, in the form of cakes or made up in various ways, per year, or a total of approximately 600,000 pounds of metal, at a value of 26 pesos per pico, amounting to 117,000 pesos.

The year 1860[3] marks the first actual production, and in 1860 and 1861, 146,470 arrobas (of 25 pounds) of mineral were produced, the

[1] Translated by A. J. Eveland.

[2] Santos: Informe, p. 19.

[3] Obtained, by courtesy of Señor Balbas, from a few of the yearly reports of the Cantabro-Filipino Company.

greatest yield being from the crushers—that is, 64,688 arrobas—with an average content of 5 per cent copper; screenings, giving 9 per cent metal, yielded 9,608 arrobas; and the production of the first and second class mineral, containing 29 and 15½ per cent copper, was 2,380 and 29,201 arrobas, respectively. The rest of the mineral consisted of mixed ores, from various localities, to about 2,200 tons in all.

In 1862, 145,000 arrobas of mineral were produced, or about 1,800 tons; in 1863, 170,000 arrobas, or about 2,200 tons; in 1864, 180,000 arrobas, or about 2,500 tons; giving a total of 666,470 arrobas up to the end of 1864, or approximately 8,500 tons of mineral.

Further production was, in 1866:

Product.	Copper.	Amount produced.	Content in metal.
	Per cent.	*Pounds.*	*Pounds.*
First class	38	7,650	2,907
Second class	20	288,302	57,072
Various, making a total of		2,509,175	234,807

No further figures are available to show the amount of ore produced from these workings. From another place[1] is taken the statement that up to 1874 there were produced by the Cantabro-Filipino Company 2,500,000 pounds of copper as a result of its operations.

In 1875 the efforts of the Cantabro-Filipino Company came to an end and it suspended work. Santos, whom the Spanish Government had loaned to the company for a considerable period of time, died at the mines, and it is supposed that the cessation of the labors of this, their guiding spirit, contributed in no small degree to the reason for the closing down.

The smelter site and the mine openings remained as they were, and the natives and the Chinos for many years reaped a harvest from this ore, smelting and refining the product in a wonderfully skillful manner. Various projects to reopen the mines came to nothing, and finally in 1898 occurred the war with Spain. In the American Army, and especially among the volunteers, which were principally Western regiments, there were many men who had spent long years in prospecting and mining in other regions, and it was not long before the localities in the Philippines reported ore bearing became known; so that it was the most natural thing in the world for those hardy men to penetrate into this and other portions of the Islands in search of mineral, even when the country was, to say the least, dangerous, as many a sharp conflict showed.

Early in 1900, in January, a party of Americans,[2] eight in number,

[1] Centeno: Memoria Geologico Minera de las Islas Filip., 1870, p. 44.

[2] If informed correctly, the party consisted of Messrs. McCauley, Wooodward, McClusky, Harvy, Malton, and Stueber. These were followed by Leonhard, Ickard, Michaels, Whitmarsh, and Gaffney—almost without an exception ex-soldiers.

Photo by A. J. Eveland.

BURIAL PLACE OF THE SPANISH ENGINEER, SR. JOSE MARIA SANTOS.

reached Mancayan, and saw, as they could not fail to do, the rich copper ores of the old mines. Claims were promptly located, and as their knowledge of the district increased, the ground farther south to Suyoc was examined and located. A month later another party came in, to be followed only a few weeks later by another. This made the district well populated in comparison to its former status, and, according to the Western (United States) customs, a "mining district" was formed and rules drawn up, even though no one knew what mining laws would prevail. For this and other reasons, owing to the unsettled nature of the Islands and its people, but little was done toward exploitation for a year or more. When the laws were promulgated and the attention of those willing and able to help was attracted, development was started in earnest, under the severe conditions which prevail. The future of this and other districts of the Islands will have much to be grateful for—to the courage and skill with which these pioneers (no less so because of a warm climate, and in modern times) forced their way and opened a way for others to follow.

CHAPTER III.

GENERAL.

GEOGRAPHY.

From the index map (Pl. I) it will be seen that the Lepanto copper area or that of Mancayan, the most important district, lies almost directly north of Manila, the barrio of Mancayan being in latitude 16° 53′ north (determined in the field) and approximately the same longitude as Manila. The latitude and longitude of Mount Datá, which is only a few miles to the east of Mancayan, is given by the Spanish authors as latitude 16° 57′ and longitude 120° 55′ west; and of Cervantes, the capital of Lepanto Province, from the same sources, latitude 17° 01′ 10″ north and longitude 120° 50′ 30″ east, approximately.

The region as a whole is in the extreme southern end of Lepanto, on the western slope of Datá, the latter a noteworthy eminence among the lesser peaks of the Cordillera de Solis. Datá, the divide between Benguet and Lepanto, and the Malaya Range form a rough basin, in which the Abra River has its origin, and on the western and northern borders of this basin the mineral-bearing ground has been exploited.

To the south lies the northward-reaching angle of Benguet and the valley of the Agno River; on the east, Datá separates Lepanto from the Asin Valley; on the west is the Malaya Range, with the valley of the Abra.

The scene of the most active work is centered at the barrios of Mancayan and Suyoc, and in their immediate vicinity. From Cervantes south to Mancayan is by direct line a trifle over 9 miles, the trail with its windings bringing this distance up to between 12 and 13 miles (about 19 kilometers). From Mancayan southeast to Suyoc is a little less than 4 miles (6 kilometers) by air line, the divide between the provinces of Lepanto and Benguet being a mile or so farther south. The exploration and development of the copper and gold deposits have been undertaken several miles south of Suyoc and for a mile or more north of Mancayan, in a belt of varying width—at its widest a mile or two—this giving an area under actual attention of 7 miles in length by 2 in width—14 square miles (35 square kilometers).

There are at present two routes to the district. The northern route, from Candon on the coast, via Salcedo, Concepcion, Teila Pass, Angaqui, and Cervantes, is a horse trail which during the dry season is in good

condition. Its difficulties consist of the steep ascent and descent of Teila Pass, and the amount of fording necessary between Salcedo and Concepcion, thirteen crossings of the river being necessary. In the rainy season the muddy condition of the trail from Candon to Salcedo, the flooded condition of the Balidbid River between Salcedo and Concepcion, and the destruction of the trail beyond practically closes this route. Another trail, a few miles to the north, from Angaqui to Santa Maria is an alternative evil. There is contemplated a new trail from Cervantes directly across the Malaya Range, down the Chico River to Tagudín, which it is believed will relieve the present conditions. This trail will shorten the journey from the coast to Cervantes and it is believed will be available during the rainy season.

The trail to the south, to Baguio, is a good horse trail, but also has the disadvantages of the numerous fords which characterizes all island travel. Baguio may be reached in from three to six days, passing via Bugias, Kabayan, Adoway, Daklán, Ambukláo, and Trinidad, and from Baguio or Trinidad two days more are necessary to reach San Fernando on the coast. At this writing there is completed, or at least open to travel, the new Benguet road—a graded carriage road from Baguio to Dagupan, the northern terminus of the railway.

The most available route, therefore, is at present by the northern trail, subject to delays and mishaps in the rainy season.

In the mineral district the main trail from Cervantes, Lepanto, to Benguet passes directly through Mancayan and one-half mile east of Suyoc. Another well-kept trail leads eastward from Mancayan into the basin on the west flank of Datá known as Balili, about 3 miles. Apart from these, there are no trails other than those of Igorot construction. These trails—footpaths over which the Igorots trudge contentedly over impossible grades in single file—form connecting links between all barrios, and are found on every ridge; while they give fair communication among the natives, they offer no solution of the transportation problem.

CLIMATE.

No meteorological data are available for the Province of Lepanto alone, but it may be said that, in common with the whole Philippine group, generally only two seasons are recognizable, the wet and the dry. From November to April the climate of Lepanto leaves little to be desired. At this time of year clear weather predominates, only the occasional mountain showers breaking the long dry season.

At the altitude of Mancayan—the highest knoll in the village being little short of 4,000 feet—the temperature is comparatively low, blankets being comfortable if not actually necessary at night, and on the upper slopes of the southern end of the Malaya Range it is affirmed that the vegetation is killed at periods by low temperature. On good authority

Photo by Martin.

TEILA PASS.

Photo by A. J. Eveland.

it is stated that actual frost has occurred. As late as July (in 1904) it is a fact that three natives died of cold and exhaustion while crossing the Malaya Range at about the same altitude as Mancayan. The mean annual temperature (for Manila) is between 26° and 27° C. (approximately 80° F.). These figures are considerably lower in Lepanto. In general, April, May, and June are the hottest months, followed by the steady rains of the period up to October and November, the entire rainy season coming between the months of May and October.

VEGETATION AND TIMBER.

As in all tropical areas, the native vegetation of Lepanto is heavy and luxuriant. The slopes are heavily covered with a growth of tree ferns, canes, grasses, and small brush, and it is only on the top of ridges that clear spaces are met. The grass of the region is a long, tough, and rank-growing variety, which, unless kept down by burning off, is not particularly good for fodder. The various varieties of cane find a multitude of uses—woven in a variety of ways for almost all conceivable purposes and for construction and clothing. Of the canes the true rattan or bejuco is not found to a large extent in this section of Lepanto. These two of the smaller growths are by far the most important, as the intermediate and useful bamboo is, in the area, not found in any but very small amount.

Of timber proper the notable examples are pine and oak. It may be noted that, according to the older residents of the district, at one time the valley of the Abra River and the adjacent slopes supported a heavy growth of pine and narra (*Plerocarpus indicus* Willd). At present there is hardly a stick of timber in the entire region within a radius of 10 miles of Cervantes. On the lower slopes, near the cultivated land, no timber whatever occurs, and it is only on the more inaccessible portions of the Cordillera del Malaya and the upper portion of Mount Datá that anything like good timber exists. The valley is but another instance of the shortsighted policy of destruction of forests when proper care is not taken, and without the slightest doubt the absence of retaining timber over this drainage area has a considerable effect on the run-off and the condition of the rivers in the flood seasons. Much of this timber was consumed by the smelters of the Cantabro-Filipino Company in their operations, and at present a demand for timber would necessitate a 2 or 3 mile haul for a small amount, and if heavy demand were made on the forests for such purposes as fuel a considerably greater distance would have to be reckoned upon. The pine growth is of good size, clear and straight, up to about 2-foot (diameter) sticks. On certain portions of the higher ridges a moderate oak growth is met. This latter is heavier south of the mineral region, in Benguet Province, but, in necessity, fairly accessible.

AGRICULTURAL.

Aside from the timber products, and the natural wild growth common to all tropical regions, Lepanto offers along certain agricultural lines considerable opportunity for development.

In all portions several varieties of the banana are plentiful, serving as a food product. The coffee, especially in the higher regions (above 3,000 feet), is of most excellent quality, and at one time large areas were under cultivation that are now given over to grass. Cacao has been tried and successfully cultivated to a considerable extent. Sugar cane on the lower portions of the area, such as the flat at Comillas, yielded in past times exceptionally good returns; and the staple product, rice, reigns supreme. The labor and care given to this particular crop by the Igorots is something prodigious, in the construction of the paddies alone. Terraces to heights of 1,000 to 1,500 feet are not uncommon, and flumes, sluices, and dams are everywhere in evidence. The bulk of the product that is not consumed on the ground is not shipped out to the coast for export, but, on the contrary, into the interior to less fortunately situated peoples. The entire valley of the Mancayan River, as well as the Abra and its other tributaries, is flanked by rice paddies. No estimate has ever been made of the value of the crop annually, but from the number of hogs, dogs, and other merchandise sold by the traders from the coast, the figures must be of large proportion. The camote (a variety of sweet potato) is even more invariably cultivated, as it is the principal article of food. It grows rapidly, bears throughout the year, and requires but little care, conditions perfectly in accord with the ideas of the Igorot.

The natives—that is, the women and children—are engaged in the cultivation of the rice and other crops. The male Igorot does but little manual labor, the cultivation of the camote patches upon which the family depends for food, the rice fields, and other crops being left to the labors of women and children. The resemblance to the American Indian in this respect is striking, the position of head of the family and the state of proprietorship of any cattle or lands he may possess being evidently sufficiently arduous labor for the Igorot. Apart from the occasional mining and smelting done by him, there is little regular industry. The mining in the wet season, the cultivation of the crops, and the care of cattle are the chief employments.

POPULATION.

Within this district lies the large town of Cervantes, the capital of the province, which is the only considerable gathering of population in a town. Others, such as Mancayan to the south of Cervantes, have but little of a collected population. In the total, the number of inhabitants of the district is not inconsiderable, but a view of the country reveals no villages of any size.

The tendency of the Igorot is to collect in groups of at most a score of huts, far up on some almost inaccessible ridge, and to avoid anything like a large village. Within a radius of a mile or two of Cervantes, Mancayan, Suyoc, and Cayan may be encountered numerous small barrios, which bring the population of the province up to 72,750.[1] Cervantes proper has a population of 1,437 civilized, but with its outlying barrios the population, as given in the Gazetteer of the Philippine Islands from the census of 1887, is 16,000.[2]

Similarly in the village of Mancayan are, according to the census of 1903, 118 civilized inhabitants, but its total population is about 1,500. The total population, almost wholly "wild," of Suyoc is 600.

GOVERNMENT.

The present system of government places directly in charge of the province and answering to the Civil Government of the Islands a governor, a supervisor or engineer, a treasurer, and a secretary. These unite as a provincial board and decide as a whole the work to be done. In the various subdivisions are native presidentes (or headmen) and their consejales (or aldermen), and purely local affairs are directed by these, subject to central supervision and command. A group of old men in each smaller village have tacit powers, and it is one of the good points in the Igorot makeup that their word has such great weight.

While it is hardly within the province of this report to enter deeply into racial characteristics, a very few words as to the nature of the inhabitants of these mining districts may not be out of place.

The Igorot is somewhat sharply distinct from the other races of the Islands.[3] He is supposed to be derived from the races of the Malay invasion which were driven inland by the later invasion from the same region. He is a sturdy savage, generally happy and content, of considerable intelligence and good disposition; from a racial standpoint, moral and honorable. He takes not kindly to labor, not from the inherent mistaken idea of the Tagal, who despises work as degrading, but from the fact that he is of the mountain, free and untrammeled, and much labor is not necessary to his existence. He is more hardy than his brother of the coasts and plains, and as further more inaccessible portions of the island are reached many fine specimens of men and women are seen.

---

[1] Of this number 70,283 are classified as "wild" and 2,467 as civilized. Census of the Philippine Islands, 1903.

[2] The census of 1903 gives no total figures for towns and barrios, so that this figure must be accepted, though of doubtful value.

[3] See Virchow, Rud.: The Peopling of the Philippines, 1897; and Jenks, A. E.: The Bontoc Igorot, Volume I of the Ethnological Survey Publications of the Government of the Philippine Islands.

In religion his ideas are crude and have more or less of an oriental tinge—in fact, a mixture of the Shintoism of Japan with the belief of the North American Indian could not be far from the religion of the Igorot. Crude as the belief may appear to Christians, it is nevertheless a religion, a belief in a spiritual authority. The respect and deference accorded to the old men has been already commented upon; the Igorot feels a moral obligation to care for his aged that is rarely exceeded.

In advancement the Igorot is a curious mingling of the most ancient and the quite modern. The agricultural implements in use are the most primitive of iron instruments, and the pointed stick is in common use. The flint-and-steel method of making fire is used in certain parts of the province, and in others the "fire gun"—a tight-fitting piston in a barrel heating the compressed air—is the means used. In his copper smelting the process used is extraordinarily in accordance with modern practice, and yet in casting objects of gold, bronze, or copper the "cire perdue" process is used, a method which is also practiced by the Burmese bell founders, and which has come down from the Bronze Age. The use of a blast cylinder is common, superseding blowing by mouth, or a bellows; the pan for washing gold is of superior pattern; and the native has progressed far enough in construction to build an arch, though a "false arch," formed by courses of stones projecting inward, one course above another, and not the more advanced type, the "true arch," of the keystone; and yet the Igorot has faith in the trial by ordeal and reckons the passing of time by the height of the sun and longer periods by the recurrence of the moon, and by the number of harvests.

AST FROM TUBOC. MONTE DA

Photo by A. J. Eveland.

TOPOGRAPHY ON GILONG CREEK.

MANCAYAN RIVER GORGE, WEST OF MANCAYAN. MOUNT MALAYA IN BACKGROUND.

Photo by A. J. Eveland.

MANCAYAN RIVER VALLEY.

Photo by A. J. Eveland.

ABRA RIVER AT COMILLAS. EASTWARD VIEW.

CHAPTER IV.

TOPOGRAPHY AND HYDROGRAPHY.

TOPOGRAPHY.

Northern Luzon, above the sixteenth parallel of north latitude, presents fairly uniformly a single topographic type. It is characterized by parallel approximately north-south mountain ranges, with extensive longitudinal valley systems. Broadly speaking, almost in the center of the island is the main chain, the Cordillera Central, and its extensions, the Cordillera del Norte and the Caraballo Sur, which forms the main watershed of Luzon. Two coast ranges, the Sierra Madre of the Pacific coast, and a series of somewhat irregular ranges on the west coast, under a variety of names, mark, with the main mass shown the roughly parallel system of mountain range and valley. From the central cordillera transversal valleys modify the regularity of the structure, and present, in central northern Luzon, a broken and irregular appearance, the region immediately to the east of the Cordillera Central being particularly irregular.

Denudation is the keynote of the topography, and although the immediate east and west boundaries of the area more closely connected with the territory under mining investigation depend to a greater or less extent on the structure, the limiting ranges on the sides being tectonic in type, late volcanic action and extreme degradation have combined to produce topographic forms unclassifiable under one head.

The regions of Mancayan and Suyoc are at the head of the Abra Valley, which has resulted from the breaking down of an anticlinal arch of wide extent, and possibly, to some degree, to faulting of the same.

On the west of this valley lie the Cordillera del Teila, an escarpment of westward-tilted sedimentaries rising some 4,000 feet above the level of the sea, and here on the east, having a precipitous slope to the valley of the Abra (at Angaqui), at the foot of Teila Pass, of 3,000 feet.

On the east the main watershed of the Cordillera Central marks the boundary of the province, and similarly this range is flanked on the east by tilted sedimentaries. The valley is terminated at the south by spurs in a northeasterly direction, which also mark the boundary of Lepanto Province.

The topography of the immediate area of the mineral exploitation is therefore of a limited area only—that of the head waters of the Abra River. Situated as this district is, on the flank of Mount Datá of the

Cordillera Central, and closely surrounded by the limiting ranges, the topographic forms are dependent to greater measure upon drainage and subsequent degradation than upon structure. The sedimentaries to the west are some little distance from this region, and those to the east, though uncovered by river action only at the immediate eastern side of the mineral district, have been buried by late volcanic material to a considerable depth. Drainage from this region is directed altogether to the north, ultimately, and the generally northern trend of the valleys in connection with the usual radial type of mountain mass erosion produces the resultant deeply eroded surface.

The small area over which mining and prospecting are being carried on rests on the west slope of Mount Datá, and a spur which extends from that mass to the west. As a whole, the slope of Datá to the western side is uniform, forming an irregular conical mass, around the base of which runs the Abra River and its tributaries. On account of rainfall conditions the erosion has been marked, and steep gorges, V-shaped, are the rule. The upper volcanic rocks of the eastern portion of the region are of a yielding nature, and erosion produces rounded forms, "hogbacks," and mounds, giving a quite regular slope to the immediate base of Datá; further to the west, where the rock masses are harder, and in the intermediate areas, where the streams cut through into the hard material beneath, the steep-sloped ravines predominate, and the drainage is divided so carefully that ridges and spurs give at the top but space for a foot trail. Lateral erosion has been deep and rapid, and a general topographic map of a large area will show a well-dissected region.

The towns of Mancayan and Suyoc are situated on the top of the less resistant material spoken of and the appearance of the area around them, rounded and rolling, is in decided contrast to the steep slopes and rapid fall of the gorges and river channels at their immediate boundaries.

HYDROGRAPHY.

The region of Mancayan, situated, as it is, on the slopes of Mount Data, is well drained by numerous streams, chief among them being the Abra and its tributaries. The course of the Abra proper is somewhat peculiar. It rises a little south of Mancayan, flowing in a *southern* direction, for a short distance, describing a semicircular course, through well-cut, V-shaped gorges to Comillas, northwest of Mancayan. From there on the course of the river is normal, winding through the broad valley between the Cordilleras de Teila and Solis.

Starting from Tuboc, the barrio nearly in the center of the district, the Mancayan River cuts an almost straight path to its junction with the Abra at Comillas. At a short distance from its origin it is entered on the east by the shorter stream known as the Mangambang, or Tabio, which rises on the Aban spur of Mount Data, and cuts the gorge of some 500 feet

Photo by A. J. Eveland.

ABRA RIVER AT COMILLAS.

Photo by A. J. Eveland.

FLOOD PLAIN OF ABRA RIVER AT COMILLAS.

THE MINING BUREAU.

Photo by A. J. Eveland.

Photo by A. J. Eveland.

MANCAYAN RIVER VALLEY ABOVE BUGIAS.

Photo by A. J. Eveland.

MANCAYAN RIVER AT BUGIAS.

through the deposits of copper at Mancayan. Farther to the east, on the upper slopes of Mount Data, the river early develops power, and, flowing westward for 1 or 2 miles, turns abruptly to the north at a right angle, and finally debouches into the Mancayan at Baguis, 3 miles above (south of) Comillas.

The River Maanse has its origin south of the Mangambang, or Tabio, on the same spur (Mount Aban), flows west to Tuboc, thence south to Cayan, where it is met by the gullies draining the northern side of Suyoc Hill, and then in a westerly direction pursues a winding course through steep, V-shaped gorges to the Abra, several miles southwest of Suyoc.

The topography and geology of the region have affected the drainage to a considerable extent, as will be spoken of later. The rivers north of Mancayan present the usual condition of mountain-river type—the torrential water course, heavy falls, a swift, deep-gorge-cutting stream debouching into the broad valley below. But south of Mancayan irregularities of drainage are met with that indicate certain orographic changes and influences due to the nature of the rock masses.

All the rivers of the region could be described as in first and second stages of development, with steep declivities. They are to considerable extent dependent upon the seasonal changes for their volume and show large variation between extremes. During the dry season, only the springs and the "old" water keep up the volume. There is a very great diminishment in volume and power, though the streams do not by any means run dry. From the beginning of the rainy season the river steadily increases in size, and becomes, after the occasional, long, steady torrents of rain, tremendous confined floods. Until the water reaches Comillas there is, in the case of the upper valley of the Abra, no chance for expansion over any considerable area, and in consequence the rapidity and power of these streams is something astounding. Streams which were but knee-deep and a few feet in width become torrents that a horse can not ford. Under these conditions erosion has been rapid and has its effect in the topographic form.

The Abra River waters above Suyoc and those of the Bat-Bat River to the east are hardly potable from the viewpoint of the European while the streams heading up in the mineral region, as the Maanse, Pacat, Mancayan, are extremely bad. A great amount of copper and iron salts is present, as well as arsenical soluble salts, and certain springs are quite poisonous. At the meeting of the Mancayan River, which is very clear, and the Mangambang River, slightly milky and brownish, there is deposited a vivid blue film or coating in the bed, which diminishes in intensity for fully 2,000 feet downstream, and the vivid blue color of the water and of the blue-coated bed produced by the chemical reaction is plainly discernible from the tops of the surrounding ridges. The explanation of this unusually strong reaction lies in the fact that the

Mangambang River, as heretofore stated, cuts directly through the deposit of the copper minerals, of the old mines, and the Upper Mancayan River drains an area more or less shattered and decomposed, with a great deal of altering iron sulphides.

The occurrence is so striking that in previous times it certainly should have been and probably was an index finger to the prospector.

There are, however, many springs among the extraordinary number with which the district is watered, a number of which give cool, clear, and pure (no analysis made) water. These waters are fairly potable.

Hot springs, while not flowing in the immediate area under consideration, are prevalent all through this mountain region. In the Province of Benguet, some 40 miles to the southwest, there are numerous active springs, which are sufficiently large in volume and temperature to be worthy of considerable attention. And in Lepanto Province, to the north of Mancayan, there exists a similar region. The nearest of these occurrences is at Comillas, less than 10 miles northwest of Mancayan on the trail to Cervantes, where the trail crosses the River Abra. Here there is a small hot spring which has been described by Centeno, under the Spanish régime, as a ferruginous sodium-chloride spring.

At Cervantes, in the flood plain of the River Abra, by which it is covered at periods of high water, are several springs, or, in all probability, several vents of the same spring, within a comparatively few feet of one another.

On these springs, as well as many others of the Islands, the Spanish Government made more or less extensive reports, and the following excerpts are chosen from the reports mentioned, as of some value. Of the Comillas springs, Centeno[1] says:

> It gushes out of an ancient wash of angular dioritic and other eruptive rocks, forming a small pool at the river, in which, notwithstanding the high temperature, which the human body hardly can bear, the Igorots are accustomed to bathe, with good results in the great variety of cutaneous diseases to which they are subject. From this comes the great faith in their waters, that these poor people have. Guided as they are by superstition in almost every act of their lives, they never bathe here without invoking the favor of the "anitos" of the spring, making a modest offering, which generally consists of a little "palay" or rice, which they throw into the pool.

Centeno gives the height of this spring as 460 meters (1,518 feet) above sea level; from the recent survey it is approximately 1,400 feet. A flow of 1.43 liters per second was recorded, or 123 cubic meters in twenty-four hours. The water is clear, transparent, inodorous, and tastes salty; neutral reaction on litmus; no gaseous emanations; temperature of the water, 50° C. (the air, 26° C., December 17, 1886); density at 0° C. and 760 millimeters is 1.004375.

[1] Memoria Descriptiva de los Manantiales de la Isla de Luzon. D. José Centeno (et al.), Madrid, 1890.

Photo by A. J. Eveland.

TOPOGRAPHY IN THE VICINITY OF CERVANTES.

Photo by A. J. Eveland.

TOPOGRAPHY ON MAANSE RIVER.

Photo by A. J. Eveland.

Analysis of 1 liter of the water is as follows:

Content.	Weight.	Content.	Weight.
	Gram.		*Gram.*
CO_2	0.060000	CaO (in the decanted liquid)	0.086016
Ca_2O (precipitated by boiling)	.006720	Na_2O	.268349
Mg_2O (precipitated by boiling)	.006882	LiO	Trace.
FeO (ferroso) (precipitated by boiling)	Trace.	So_3	.132532
SiO_2	.074400	Cl	.316655
FeO (in the decanted liquid)	.180000		

Residue obtained by the direct evaporation of 1 liter of water and dried at 180° C. (approximately) weighed 0.851000 gram. It is calculated from the analysis that 1 liter of water at 50° C. contains in solution:

Content.	Weight.	Content.	Weight.
Cubic centimeters.	*Gram.*		*Gram.*
O 3.965000	0.005669	$FeSO_4$	0.018339
N 7.930000	.009961	NaCl	.506678
CO_2 (free) 17.556375	.034669	LiCl	Trace.
$CaCo_3$	.017280	FeCl	.016427
$MgCo_3$	.021653	SiO_2	.074400
$FeCO_3$	Trace.		
$CaSO_4$	.208896	Total	.913972

The Cervantes spring issues from the margin of the river, at a height (Centeno) of 435 meters above sea level, at a rate of 0.24 liter per second.

The water is clear, transparent, uncolored, inodorous, with a slightly salty, hard taste. It gives out bubbles of gas, and the litmus paper shows a neutral reaction. The temperature of the water is 56° C. (air, 25° C.) and density at 0° C. and 760 millimeters is 1.004732.

Anhydrous substances in 1 liter of the water are as below:

Content.	Weight.	Content.	Weight.
	Gram.		*Gram.*
Co_2	0.004000	So_3	0.521888
SiO_2	.032000	Cl	.335456
CaO	.237440	Al_2O_3	Trace.
MgO	.005125	$CaCo_3$	Trace.
Na_2O	.426687	Organic matter	Trace.

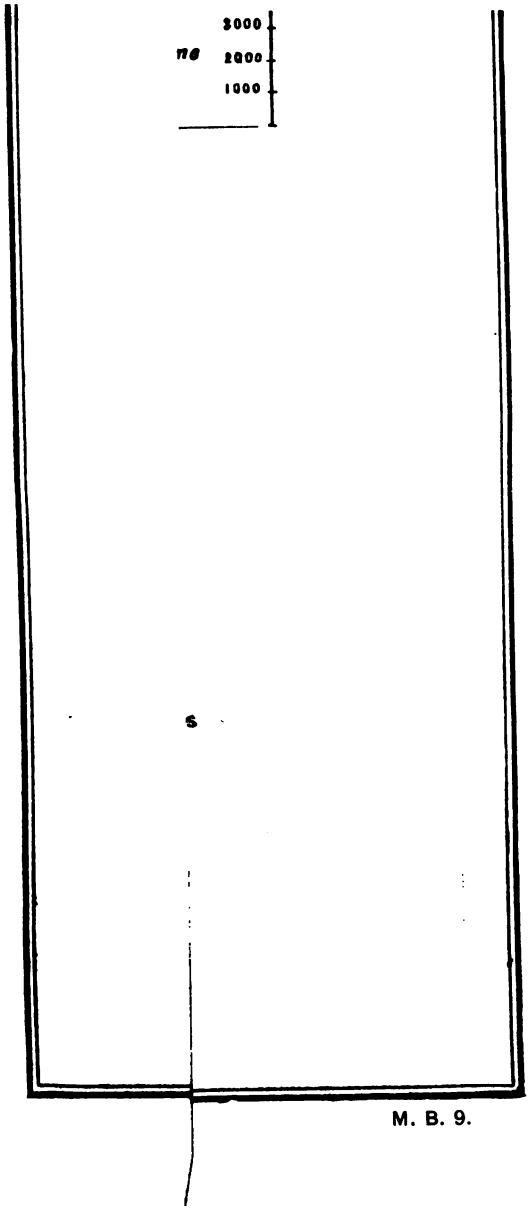
Residue obtained by evaporation of 1 liter = 1.483000 grams.

Resulting from the analysis, it is computed that 1 liter of this water at 50° C. contains in solution:

Content.	Weight.	Content.	Weight.
Cubic centimeters.	*Gram.*		*Gram.*
Co_2 2.025598	0.004000	$CaCO_3$	Trace.
Air 10.689488	.013828	SiO_2	0.032000
$CaSo_4$	.576640	Al_2O_3	Trace.
Na_2SO_4	.324147	Organic matter	Trace.
NaCl	.538121		
MgCl	.012000	Total	1.500736

Both these springs, it is claimed, have a decided medical value, and are largely used by the natives both for bathing and drinking purposes.

At Angaqui are other springs of a sulphurous nature, and in the eastern portion of the province are also many saline and hot springs, all of which constitute a feature of this and much of the rest of the Island of Luzon.



M. B. 9.

CHAPTER V.

GENERAL GEOLOGY.

LOCAL AND STRUCTURAL.

The geology of the limited area in which ore deposits are found is dependent, similarly to the topography, to a considerable extent on the general conditions of northern Luzon. Up to date but little has been known of the geologic conditions north of the central plain of Luzon, and, aside from disconnected notes made by occasional visiting geologists, the geology of the entire northern part of Luzon was mere conjecture. The Spanish authorities made an occasional visit to certain localities, one of which (Hernandez's inspection of the Lepanto area) has already been noted,[1] and, noteworthy among the others, Mr. R. von Drasche visited this area in 1875 and gave to the public his observations. Before these observations and deductions of Von Drasche, rapidly made but showing a thoroughly trained mind, the views as to the constitution of this part of the island were quite at a loss for some facts to tie to. Semper[2] speaks of the "trachytic core" of the island, and the adjacent and overlying sedimentary strata of recent age. J. Roth,[3] a short time later, compiling the information available at that time, states that "on a formation of crystalline schists" lie the Tertiary strata. Roth's conclusions were drawn from the observed occurrence of schists in the Islands of Cebu, Leyte, Mindanao, and in the Camarines Provinces of southern Luzon, and also the occurrences noted by Itier[4] of stream pebles at Angat, in Bulacan Province.

Mr. Becker in this report,[5] which gives us the most complete and concise statement of all known information, draws the inference that the crystalline schists are predominant in the basal mass of the Islands; and reasoning from analogous conditions in Borneo, and the observed facts of the known occurrences of ore deposits associated with schists or crystalline massives, he so summarizes the previous observations.

From the slight amount of work already done it seems probable that the schists do not occupy as important a place as taken for granted by Mr. Becker, but that, as Abella generalizes,[6] the diorites and dioritic

[1] See page 15.

[2] Die Philippinen und ihre Bewohner. 1869.

[3] Constitucion Geologica de Filipinas.

[4] Bull. Soc. Geog., Paris, 3d series, Vol. V, 1845.

[5] Geology of the Philippine Islands, 1901, U. S. Geological Survey, Twenty-first Ann. Report.

[6] Apuntos fisicos y geologicos. 1884.

rocks in general are the oldest rocks, at least north of the great plain of Luzon. As far north as the Province of Abra, my observations have borne this out, and in this region, west of the Cordillera Central, no schists have been observed.

From the west coast of Luzon, particularly at Candon, the point on the coast at which the party disembarked, to the Cordillera Central, at the mass of Mount Data, the general relations of the rocks are as seen by a reference to the ideal section.[1] The sedimentaries outcrop a mile or so east of Candon, at that locality dipping 40° northeast; between Candon and Concepcion gentle folding has taken place, and the valley of the Balidbid River exposes recurrent anticlines and synclines, the region bearing a striking resemblance to the Potomac River valley and others of like type in the Piedmont area in Pennsylvania, Maryland, and Virginia.

At Concepcion, which is situated in a flanking valley at the foot of the west slope of the range, the tilted sedimentaries are a prominent feature of the landscape. Great jagged blocks are tilted up against the main mass of this range, giving the slope a peculiar flat and geometrical effect.

At the crest of the Cordillera del Teila, as the coast range at this point is called, appears a great thickness of limestone, dipping to the southwest, and below it a heavy, thick conglomerate, cropping on the eastern scarp. The upper limestone, of a thickness of hundreds of feet, forms the crest of the range for an unknown distance; no fossils were collected during the hasty march, but in all probability search will reveal some organic remains; Santos quotes Semper as authority for the determination of nummulites from these beds, in abundance, and for the statement that the nummulites "have up to now occurred in the Eocene ('paleo thérico de M. Cordier') or in the immediately adjacent Upper Cretaceous." Becker[2] cautions the geological observer from inferring an upheaval from inclined stratification, but on account of the adjacent conglomerate and slates it is fairly certain that the tilting of the limestone may be traced to structural causes, and that the question of coral growth and pseudo-stratification does not enter here.

The basal conglomerate is also of great thickness, and, while on stratigraphical grounds it may not as yet be correlated accurately, it would appear from the continuity of these sedimentaries, observed from occasional peaks in going to the south through Benguet, and on lithological grounds, that these are the extension of the "Agno beds" of Von Drasche. In the Agno River they are described by Von Drasche as consisting in the lower portions of coarse breccias and conglomerate of dioritic rocks, very coarsely bedded, with pebbles often of enormous size

[1] Plate XXIII.

[2] Op. cit., p. 561.

Regarding the ages of these rocks nothing can be said except the deductions already made by others. In the present work economic problems were of the first importance and these sedimentaries apparently have no specific connection with the ore deposits of Lepanto. Von Drasche[1] first classed them as primitive, then Paleozoic. Later, Abella seems to have obtained fossils in the upper strata, of shells of surviving species, and lignite, and adopts the hypothesis that these Agno beds represent the basal conglomerate formed during the Miocene subsidence of the Philippine group.

Mr. Becker remarks in this connection that "it is tempting to seek in them (the Agno beds) the equivalent of Mr. Verbeek's breccia stage of the Eocene, which consist of unfossiliferous strata underlying Stage *a*; but the absence in the region of Benguet of the Cebuan lignitic series and the character of the organic remains appear to indicate that this portion of Luzon was above water during Eocene time." It may be possible that the tentative suggestion of this correlation may be later worked out, as it has happened that lately a small seam of lignite has been discovered on the Benguet road in this region. As it was not seen, its relations to the Agno beds are not known, and the coming field season in this area may throw some light on the subject.

The valley of the Abra River is cut, from these sedimentaries on the west to the Cordillera Central, in igneous rocks of various composition. With the exception of an olivine basalt (?) noted near Cervantes, no general lines were followed until the Mancayan district was reached.

Here, after study of the area, the structure reveals an underlying diorite, the occurrence of which again confirms Abella's deductions.

Various igneous intrusions have taken place in the basal diorite, one of the most noteworthy having a considerable expanse immediately west of Mancayan, the Mancayan River roughly following the contact between the two for a mile or more. This mass seems to have no relation to the economic aspect of the region, and, except for a description of the rock (called the Bagan granite, from its occurrence on the mountain of that name), will not be noted further. Other intrusions, and especially a mass at Suyoc, seem to have some bearing on the ore deposits and will be taken up. Except for the more important rocks of those having a direct bearing on the economic problem of this district, geological work on the rocks of this region will be reserved until suitable mapping may be done.

One of the most important masses, however, is the "trachyte" of Santos and von Drasche, which predominate to the east of Mancayan. The basal diorite, named the "Mancayan" diorite from its best exposures in the river of that name, is overlain to a variable depth, by a crystalline, neovolcanic rock, classified, as stated, as sanidine-trachyte by Von Drasche, and by Santos expressed as "porfido arcilloso;" this Mr. Becker translates

[1] I again have to thank Mr. Becker for his valuable résumé of past explorers; from his report is taken most of the following.

as argillaceous porphyry, and interprets as a quartzless, partially decomposed lava. This igneous rock outcrops on the west side of the hill on which is situated the town of Mancayan, and the contact follows a north-south approximation through Suyoc into Benguet. The same rock was observed at the town of Daklán, in Benguet, over 30 miles south, and is evidently some extensive lava flow of late age. Facies of this occurrence were observed on the western slopes of Mount Data, and from the topography and structure of the region it is thought that the source of the outburst should lie to the east. Mount Data has been alluded to generally as an extinct volcano, and mention is made of a crater lake at its summit by Meyer.[1] He states that he ascended Data (in 1882), measured its height by barometer as 2,245 meters, and found a lake 1,100 yards in diameter on a bench on the eastern slope of the highest part of the mountain.

None of those who have given to the public notes on this region have made mention of *sedimentaries* on the west slope of Data. These clays and limestones were observed in a river cutting the base of Mount Data dipping about 20° to the east. Over the upturned edges of these rocks, which have a section of some 500 or 600 feet exposed by waterfalls, spreads the "trachyte" of Von Drasche, and the upper portion of the mountain is, as far as is known, of the same material.

Judging from the structure, therefore, it is at least open to doubt if the mass of Data, as generally supposed, is the remains of an extinct volcano, or whether Data is the residual mass left by erosion of the eastern limb of the broken anticlinal arch added to by later volcanic action, either intrusive or effusive. It is certain, however, that limestones and a small seam of coal do outcrop on the eastern flank of Data and that at Cayan, or its vicinity, east of Cervantes, the limestone is again met with, these limestones containing numerous forminifera (nummulites), according to Semper.[2] If Data is of volcanic autogenesis, the activity was probably of a laccolithic type, intrusive, and not of the general mountain-building type prevalent generally in the Islands.

ROCKS.

The massive igneous rocks of this locality are represented by diorite, granite, quartz porphyry, trachyte, and one or more varieties of igneous intrusions that are not described. It is unfortunate that many rock analyses and determinations could not be obtained in time to be of service as data for this report, and also that in spite of every effort it was found impossible to prepare thin sections of one of the most important rocks in the district, the "trachyte" of Von Drasche. Due to the decomposed nature of this mass and the somewhat limited mechanical facilities at service, no satisfactory section of this rock is ready, and the additional lack of analyses prevents more than a megascopic description of it.

[1] Weltreise, 1890, pp. 253–287.

[2] That is, if Santos has quoted correctly.

Photo by A. J. Eveland.

LOOKING NORTH DOWN THE VALLEY OF THE NAPACUA

Photo by A. J. Eveland.

NEARER VIEW OF THE SEDIMENTARIES OF PLATE XXVII.

Photo by A. J. Eveland.

OLD SPANISH ROAD TO COPPER MINES, MANCAYAN, SHOWING CONTACT BETWEEN OVERLYING QUARTZ-PORPHYRY AND MANCAYAN DIORITE.

THE MANCAYAN DIORITE.

The diorite of this locality, the "Mancayan" diorite, is, on megascopic inspection, a dark-green granular rock, coming well under the field classificatory [1] name of diorite. Within the Lepanto area it is uniform in texture and structure, showing unusually little of the variability of dioritic types. As noted before, the same type is noted in Benguet and other areas, and there are good grounds for believing that the diorite is a widely extended mass.

The relative size of the hornblende and feldspar give the rock its color, and in a hand specimen the amphibole is apparently predominant. On weathered surfaces, however, the feldspar stands out in light-colored lath or rod-shaped crystals, within a matrix of the amphibole. No other minerals are noted, megascopically.

In the examination of the thin sections there is revealed a plagioclase, in rod or lath shaped crystals, involved in a matrix of green hornblende. The plagioclase, as seen on symmetrically cut twins, is apparently labradorite, evidently of earlier formation than the hornblende. This reversal of the normal order of crystallization produces the pseudo-ophitic structure noted. The feldspar is white, cloudy, with dull, earthy luster; no zonary banding observed in the limited sections and no kaolinization to a great extent.

The next important mineral, the hornblende, occurs in flakes and very fragmentary masses surrounding the feldspar lathes; light green in the section and has a low extinction angle which can not be exactly determined, owing to the fragmentary nature of the mineral. No uralitization was noted, though the transposition of gabbros or diabases to this diorite may not be positively denied.

No quartz present, nor mica. Olivine occurs in rounded grains in the hornblende, showing slight alteration. Magnetite also noted, in typical forms.

Four analyses [2] of the Mancayan diorite follow:

	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture, 110°	0.50	0.28	0.38	0.12
Loss on ignition	2.74	1.38	.70	2.26
SiO_2	50.67	51	47.98	47.94
Al_2O_3	21.21	18.01	18.94	21.96
Fe_2O_3	11.31	.23	7.08	2.48
FeO	.21	9.31	3.98	3.42
CaO	6.86	8.89	11.01	12.63
MgO	4.10	6.53	7.06	6.83
K_2O	.10	.46	.44	.19
Na_2O	1.41	4.42	2.56	1.49
Total	99.11	100.51	100.13	99.35

[1] Cross, Pirsson, Iddings, Washington: A Quantitative Chemico-Mineralogical Classification and Nomenclature of Igneous Rocks. Chicago, 1902.

[2] Analyses by Mr. L. S. Salinger, Bureau of Government Laboratories, Manila, P. I., 1905.

Local variations may possibly explain variation in these analyses, in the instances of the lime and ferric-oxide content. The lime appears rather above the normal for this type of rock, as are the alumina and magnesia to a lesser degree. The remaining constituents appear about normal.

THE BAGAN GRANITE.

This intrusive mass, the contact of which with the Mancayan diorite is followed by the Mancayan River, west of the town of the same name, is a light-colored, medium and evenly grained rock, seen by megascopic inspection to consist of quartz, orthoclase, and hornblende. It is evidently holocrystalline, and typically granitoid in texture, coming under a "granite" in a field classification of phanerites. At its contact with the Mancayan diorite, sharp and clearly defined, from interfingering of the two masses, most of the places seen indicate that the granite is later than and intruded into the older diorite. Alteration or metamorphic action has taken place only to a very limited extent, and in many instances sharp angular "horses" of the diorite are included in the granite, near the contact, with no change whatever.

Under the microscope this rock is readily classified as a hornblende granite, showing quartz, feldspar, and hornblende only, in the slides examined.

The quartz is typical of similar occurrences elsewhere—xenomorphic colorless grains and masses, glassy in its pelucidity and clearness, with numerous dust particles and gaseous inclusions.

Both soda and lime feldspars occur, with orthoclase predominant, in simple crystals, and numerous twins. Little of the feldspar is fresh, and it shows the typical decomposition structure, with well-marked cleavage planes and pearly luster.

The hornblende is also normal. Irregular masses, showing prismatic cleavage; the ordinary green variety is predominant, and occurrence of glaucophane (?) is noted. Other facies of the same rock give the more common brown of the hornblende, and in these some slightly more idiomorphic forms are noted.

Magnetite and possibly other iron minerals occur in abundant groups of crystals. There are also small inclusions, indeterminate, of a highly refractive mineral, which suggest possible titanite. Apatite occurs in small amounts.

Photo by A. J. Eveland.

SOUTH FROM MANCAYAN, SHOWING MANGAMBANG RIVER GORGE.

Analyses[1] of this rock follow:

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	0.02	0.13	0.20
Loss on ignition	.39	.84	1.01
Silica (SiO_2)	77.21	73.56	71.80
Alumina (Al_2O_3)	15.38	1.42	2.46
Ferric oxide (Fe_2O_3)	.72	1.27	1.93
Ferrous oxide (FeO)	.93	14.30	14.28
Lime (CaO)	2.18	2.50	2.96
Magnesia (MgO)	.42	.79	.22
Potassium oxide (K_2O)	.50	.38	1.54
Sodium oxide (Na_2O)	2.26	5.09	3.02
Total	100.01	100.28	99.42

THE QUARTZ PORPHYRY.

This rock, the mass characterized by Santos[2] as "porfido argilloso," or argillaceous porphyry, as Becker translates it, occurs on the western side of the Mancayan hill, resting on the Mancayan diorite beneath. This one outcrop extends a distance of several miles, disappearing north and south under the "trachyte" which covers it at Mancayan. There are to the north several smaller outcrops, isolated masses or islands, and the whole mass has been the subject of considerable conjecture and limited study, having, as it does, a direct bearing on the ore deposits of the copper region.

Santos[3] describes it as "a quartzose mass in a vertical position, not more than 80 or 100 meters in thickness, which strikes northwest, and is exposed at the southeast by a great cut, partly due to the mining operations of the natives. Toward the northwest it is partially concealed and disappears under argillaceous porphyry (porfido argilloso), which is more recent. The siliceous mass is of the same character throughout its extent; it is sometimes compact, sometimes crystalline, often porous, and always charged with iron pyrite. It contains decomposed feldspar in irregular veins, or porphyritically disposed. The croppings are of columnar form. The whole mass is fissured or jointed in different directions." Mr. von Drasche later visited this locality, but could not discover the rock relations. He speaks[4] of the rock as a rhyolitic quartz-trachyte, which shows flow structure, with variations in the color of the ground mass from dark gray to red. In this thick, hard, splintery ground mass are quartz fragments, extremely numerous. They are never rounded nor do they show other than a regular character; they attain a thickness of 4 millimeters. Thin sections gave him no clue to the nature of the ground mass, but he states that it is evident that the

[1] Bureau of Government Laboratories.

[2] Op. cit.

[3] Informe sobre las minas de cobre, p. 25.

[4] Von Darsche, Fragmente, p. 37.

quartz fragments have not come from the ground mass and that they were "wrapped up" by the still fluid magma.

The two descriptions already given cover fairly well the general aspect of this rock—it is a hard, flinty, red to yellow-white quartz leucophyre with prominent quartz phenocrysts. Nothing can be made of this ground mass with the naked eye, and the study of the thin section reveals little but that it is extremely siliceous. The quartz seems to be perfectly clear and often perfect in crystalline form, and the doubly terminated hexahedron predominates. There is little or no superficial weathering of the rock mass, though the entire rock shows great alteration, and is without doubt a product of metamorphic processes. Under the microscope the porphyritic nature of the rock is more clearly visible—whole and fractured quartzes set in a quartz-feldspar paste from which little can be determined. Spaces of dissolution are a prominent feature of the rock, occasionally giving a cellular structure, and the presence of pyrite and magnetite is everywhere noteworthy.

From the few sections at hand, none of which proved to be entirely satisfactory, little positive information could be gathered. It does not appear, however, that Mr. Santos's conception of the mass can be regarded as correct; careful search was made for the columnar structure he noted, but beyond a series of cross fractures which form a noticeable characteristic of the exposure, it is certain that he must have been misled. Similarly, there is not the slightest hint of sedimentary origin in any of the exposures or thin sections examined.

Mr. von Drasche's necessarily hasty observations, leading to the view that this mass is a lens of quartz embedded in the trachyte, are not substantiated by a more careful study of the structure of the region, and hence this view is regarded as improbable.

All the evidence at hand points to a contact zone of limited extent, produced by the Mancayan diorite being covered by a considerable flow of the "trachyte." Both microscopic and megascopic evidence show that the quartz porphyry is not original as such, and that but little of it, except the quartz, has existed unchanged since its formation.

Three analyses [1] of the quartz porphyry are given below:

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	0.22	0.11	0.00
Loss on ignition	1.24	2.70	3.18
Silica (SiO_2)	89.49	90.60	87.96
Alumina (Al_2O_3)	4.88	.07	3.75
Ferric oxide (Fe_2O_3)	4.24	3.15	3.89
Ferrous oxide (FeO)	.05	1.15	.69
Lime (CaO)	.04	.08	.08
Magnesia (MgO)	.32	.58	.23
Potassium oxide (K_2O)	.08	.16	.11
Sodium oxide (Na_2O)	.25	.70	.39
Total	100.81	99.30	100.28

[1] Analyses by L. A. Salinger, Bureau of Government Laboratories, Manila.

THE TRACHYTE.

Covering all to the eastward of a line from Mancayan to Suyoc, and apparently over a much greater general area, is a rock which Von Drasche classifies as a hornblende-sanidine-quartz-trachyte, and from lack of other than megascopic inspection for a guide, that name, or more simply quartz-trachyte, expresses the rock as nearly as may be.

It is a much-decomposed granular-to-porphyritic mass, which weathers to varicolored clay, giving an appearance to the soil which may not be mistaken. In all the field work no absolutely fresh specimen could be obtained and those collected have altered in the laboratory.

There is present a noticeable amount of quartz in clear, rounded, fracture grains and prominently in doubly terminated hexahedrons; feldspar in short, tabular crystals, much decomposed; clear sanidines with typical luster and twinning; a ferro-magnesian mineral, indeterminate as to amphibole or pyroxene, in somewhat noteworthy amount; occasional biotite; considerable magnetite. The placing of the feldspars in the general mass gives the typical orthophyric structure, as opposed to the more common trachytic structure; the proportion of ground mass varies locally, but in all cases it is subordinate to the phenocrysts, approaching a pronounced granitoid texture in cases.

Below are given several analyses [1] of the rock, made from imperfect field specimens. With no microscopic examination possible, and only the aid which the divergent and not representative analyses give, it appears that more exact determination may better be left to more detailed work in the Mancayan region. The name given by Von Drasche appears to be sufficiently definite for the purposes of this report and the rock will be so designated.

Analyses.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	1.58	1.84	3.83
Loss on ignition	4.82	7.04	2.23
Silica (SiO_2)	54.80	68.31	60.48
Alumina (Al_2O_3)	19.29	18.18	18.11
Ferric oxide (Fe_2O_3)	1.83	2.15	3.14
Ferrous oxide (FeO)	2.54	.37	1.67
Lime (CaO)	8.21	.24	4.94
Magnesia (MgO)	3.11	.25	2.12
Potassium oxide (K_2O)	2.50	.98	1.38
Sodium oxide (Na_2O)	1.55	None.	2.40
Total	100.23	99.36	100.30

[1] Analyses by L. A. Salinger, Bureau of Government Laboratories, Manila.

THE MINING BUREAU.

Photo by A. J. Eveland.

Photo by A. J. Eveland.

OLD NATIVE WORKINGS AT SUYOC.

CHAPTER VI.

ORE DEPOSITS.

MINERALOGY OF THE ORES.

GANGUE MINERALS.

Under the head of gangue minerals are included those most intimately connected with the metallic minerals of the lodes, and which form the matrix of the latter. The term is used in its commonest sense, to signify the constituents of the lode that occur in intimate connection with the mineral under exploitation, and as the ores of this district are of a prevailing type, no ambiguity will result.

Quartz.—Comp. SiO_2, oxide of silicon = oxygen 53.5, silicon 46.7 = 100. Massive or in hexagonal prisms terminated by rhombohedrons. Often in double six-sided pyramids. Generally white or colorless. Hardness = 7. Sp. gr., 26. Luster, vitreous, sometimes greasy. Transparent to opaque.

The quartz of this region shows essentially the same characteristics of vein quartz that occurs in most mining districts. There is present a comb-structure quartz showing "crustification," or banded-vein structure, having its origin in the filling of fissures either by growth in an open space or by slow expansion of a mere crack. The quartz of the Mancayan mines is hard, tough, compact, of a resinous luster, much shattered, and of a fine grain. The quartz from this locality is, from its observed nature, due almost entirely to secondary action of silicifying solutions. Replacement of other minerals and the filling of rock fractures have produced a quartzose mass, the bulk analysis of which shows a high per cent of silica. Such rock in thin sections under the microscope may reveal skeleton-like forms of crystals of other minerals, replaced entirely or partially by silica.

Almost without exception the vein-filling material of the region is quartz, the proportions of other minerals present being variable. There are, besides, occurrences of minerals other than quartz in that capacity which may be spoken of.

Barite.—Barytes. Comp. $BaSO_4$, barium sulphate, orthorhombric, commonly in tabular crystals, in divergent form, or massive. From its high specific gravity (4.5) it takes the name "heavy spar." Cleavage perfect in three directions. White. Transparent to opaque. Sometimes yellow, gray, brown, or red. Barite is less important as a vein material in this region, but its occurrence is noted.

Calcite.—Calc spar. Comp. $CaCO_3$, calcium carbonate = carbon dioxide 44, lime 56 = 100. Rhombohedral. Cleaves perfectly in three directions, producing rhombohedrons. Commonly in this form, or prisms, scalenohedrons, or massive. Color variable, where impure, generally white or colorless. Transparent to opaque.

Unimportant as a vein material, though occurring throughout the district. Found in abundance as a microscopic constituent of lode materials.

Kaolinite.—Kaolin. Comp. $H_4Al_2Si_2O_9$ or $2\ H_2O.\ Al_2O_3.\ 2\ SiO_2$ = silica 46.5, alumina 39.5, water 14 = 100. Monoclinic. In scales or plates, and generally in fine white powder. Occurs as clay-like masses, compact, mealy, or friable. H. = 2–2.5. Sp. gr., 2.6.

This mineral occurs throughout the district, and especially in the Suyoc region, as a result of the decomposition of rock material, aluminous minerals, and feldspars. At Mancayan veins of several inches in thickness run through the upper trachyte; these are very pure kaolin, of a good white color. They crop out south of the village on the main trail.

Gypsum.—Comp. $CaSO_4$, $2\ H_2O$, hydrous calcium sulphate = sulphur trioxide 46.6, lime 32.5, water 20.9 = 100. Monoclinic, varieties selenite in transparent tabular crystals, to massive, often fibrous, cleavage on one plane eminent, giving foliated structure. H. = 1.5–2. Sp. gr., 2.3. Luster, subvitreous to shiny. Color usually white; varieties, where impure, colored. Transparent to opaque. The occurrence of gypsum at Suyoc is suggestive of recent volcanic activity. In the gorges of the Pacat Rivers and other drainage streams of Suyoc hill occur numerous veins of gypsum, often of considerable extent. These veins are of the fibrous variety, the widest observed giving a length of about 2 or 3 feet to the curved transverse fibers. Some of the rich values of that particular region were, it is claimed, taken from one of these veinlets.

ORE MINERALS.

This heading embraces the minerals of this district, which are generally mined for ores, or value of some nature, although it may be borne in mind that local conditions determine to a great extent just the heading that certain minerals come under. The minerals of this list, unless attention is called to it, have all a metallic luster.

Gold.—Comp. gold. Isometric, but rarely showing crystalline form. Usually in irregular particles, filiform dendritic shapes, "wire" gold. Thin plates, rounded edges, and flattened grain or scales. Cleavage none. Fracture hackly. Very malleable and ductile. H. = 2.5–3. Sp. gr., 15.6–19.3, 19.33 when pure. Luster, metallic. Opaque in ordinary masses.

In the Lepanto mining districts most of the attention has been directed to the free-gold workings.

At Suyoc, where visible gold is to be observed, the metal occurs in fine

Photo by A. J. Eveland.

OLD NATIVE WORKINGS ON QUIEN SABE VEIN, SUYOC.

Photo by A. J. Eveland.

ANCIENT SUYOC WORKINGS.

plates and grains in small quartz seams, in connection with sulphides of copper, zinc, and lead. The natives work only the free gold and have no knowledge of other values. Farther north the gold values seem to be more closely confined to iron pyrites, and less to the other sulphides. In Mancayan gold values are obtained from both the copper ores of the district and the quartzose vein matter of Mancayan and Tuboc.

Pyrite and marcasite.—Pyrites, "iron" pyrite, "white" iron. Comp. FeS_2, iron disulphide = sulphur 53.4, iron 46.6 = 100. Isometric, pyritohedral, cube and pyritohedron (pentagonal dodecahedron), octahedron, or combination of these, the common forms, sometimes striated. Frequently massive, and finely granular. Color, pale brass yellow to whitish. Luster, metallic. Opaque. H. = 6. Sp. gr., 5. The common sulphide of iron here, as generally in mining districts, is common in all of the ores of the region, and to a greater or less extent present in the rock masses in the vicinity of the ore deposits. In this region the pyrites occur alone, in quartzose veins, associated or not, as the case may be, with other sulphides, and in the Mancayan ore, closely connected with the sulpho-salts of copper which constitute the ore of that region. While, as has been before noted, the pyrite of Suyoc is not worked for gold by the natives, not enough samples of it have been taken to demonstrate that it carries no values. As noted before, it is as yet undetermined just what relationship the pyrite and the gold values have, but as this district opens up more information on the point will be obtained, it is presumed.

Galena or galenite.—Lead glance, "lead." Comp. PbS, lead sulphide = lead 86.6, sulphur 13.4 = 100. Isometric, cubes predominating. Perfect cubic cleavage. Massive, granular, or finely granular, occasionally fibrous. Color, lead gray. H. = 2.5–2.75. Sp. gr., 7.4–7.6. Luster, metallic. Opaque. Generally argentiferous.

Galena is, compared with other minerals, not prominent in this region. On the Suyoc area alone it is observed, and here in connection with other sulphides in small amounts in quartz veins. Outside of the Suyoc area the quantity of galena occurring is practically negligible, so far.

Sphalerite.—Zinc blend, blende, black jack, "zinc." Comp. ZnS, zinc sulphide = zinc 67, sulphur 33 = 100. Isometric, tetrahedral, commonly massive; cleavage granular to compact. Brittle. H. = 3.5–4. Sp. gr., 3.9–4.1. Luster, resinous. Color, commonly yellow to black. Transparent to translucent. Occurs in considerable amounts in the Suyoc area, in conjunction with sulphides of copper, lead, and iron.

Chalcocite.—Copper glance. Comp. Cu_2S = copper 79.8, sulphur 20.2 = 100. Orthorhombic crystals, pseudo-hexagonal, twinning. Massive granular to compact. Brittle. Luster, metallic. Color, lead gray, often tarnished blue or green. Opaque. H = 2.5–3. Sp. gr., 5.5–5.8.

Occurs in the Mancayan area with other copper minerals.

Bornite.—Purple copper ore, peacock copper. Comp., a sulphide of

iron and copper, variable (Cu_3FeS_3 = sulphur 28.1, copper 55.5, iron 16.4 = 100). Isometric, cubic. Massive, granular or compact. Brittle. H. = 3. Sp. gr., 4.9–5.4. Luster, metallic. Color, copper red to brown, iridescent. Opaque.

Observed mineralogically, with other copper minerals of Mancayan.

Chalcopyrite.—Copper pyrite, yellow copper. Comp. $CuFeS_2$ = sulphur 35, copper 34.5, iron 30.5 = 100. Sulphide of iron and copper, variable, due to admixtures. Crystals commonly tetrahedral. Massive, compact. Brittle. H. = 3.5–4. Sp. gr., 4.1–4.3. Luster, metallic. Color, brass yellow, often tarnished. Opaque.

This is present in variable amounts throughout the district. Generally in quartz veins associated with other sulphides.

Tetrahedrite.—Gray copper. Comp. 4 Cu_2S, Sb_2S_3 = sulphur 23.1, antimony 24.8, copper 52.1 = 100. Composition variable. Sulphide of copper and antimony. Isometric, tetrahedral. Rather brittle. Luster, metallic. Color, flint gray to tin black. Opaque, translucent (red) in thin splinters. H. = 3.4. Sp. gr., 4.4–5.1. Arsenic and antimony are generally present and composition of this mineral is extremely variable. The high percentage of copper in this mineral (approximately 52 per cent), as well as its abundant occurrence in the mine of the Cantabro-Filipino Company at Mancayan, makes this one of the most important of the region. It is also found in the Suyoc area, on various claims of that region.

Enargite.—Comp. Cu_3AsS_4 or 3 Cu_2S, A_2S_5 = sulphur 32.6, arsenic 19.1, copper 48.3 = 100. Orthohombric, crystals usually small and striated. One perfect cleavage. Brittle. H. = 3. Sp. gr., 4.43–4.45. Luster, metallic. Color, grayish black to iron black. Opaque.

This mineral, as well as tetrahedrite and other copper-sulphur salts, constitutes the greater part of the large ore body of the Mancayan mine. Occurring with this is luzonite, composed essentially as enargite, but differing in crystallization.

Several analyses of the typical ore from the Mancayan mine are given below:

	I.	II.	III.	IV.	V.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Insoluble residue		49.19	55.93	66.72	30.10
Silica	47.06	45.91	45.31	64.53	23.40
Sulphur	24.44	20.36	15.40	12.98	23.58
Antimony (metallic)	5.12	None.	None.	None.	None.
Arsenic (metallic)	4.65	2.26	.43	1.80	.40
Iron (metallic)	1.84	14.25	8.98	8.96	11.13
Copper (metallic)	16.64	13.90	16.54	9.72	32.92
Lead (metallic)		None.	None.	None.	None.
Loss	.25				
Total	100	99.96	97.28	100.18	98.13
Gold (ounce)		0.23	0.16	0.08	0.04
Gold value, at $20.67		$4.75	$3.31	$1.65	$0.83

Photo by A. J. Eveland.

No. I is from Santos's Informe (p. 38) and is given as the mean composition of the different ore breasts of the native workings.

II is a piece of *ore* from the "Carmen" workings of the Santa Barbara mine, Mancayan, selected as typical.

III is a sample taken of the ore the natives (Igorots) use in their smelting, probably from different portions of the Mancayan mine.

IV is another sample taken as typical of the "Santa Barbara" ore.

V is a rounded bowlder of apparently almost pure copper mineral; to the glass it reveals only crystallized enargite, with some very slight amount of quartz and an occasional bunch of chalcocite.

It is not known by whom the analysis was made for Mr. Santos. The analyses numbered II to V, inclusive, are from the Bureau of Government Laboratories, Manila, to which work of this character is submitted.

Another specimen of ore was examined [1] mineralogically by Dr. W. E. Ford, of Yale University, with the following result:

> The specimens show the characteristic crystals of enargite in the cavities. They are elongated parallel to the vertical axis and show their orthorhombic character by the shape of their cross section. For the most part the faces are not well developed, the prism zone showing the deep striations characteristic of the mineral. The blowpipe tests agree with those required by enargite.
>
> The most prominent mineral of the specimens is a massive mineral which on a weathered surface has a dull-bronze color, but which on a fresh fracture shows a reddish-gray tone. No evidences of crystallization could be discovered. Its fracture is uneven. Its blowpipe and chemical reactions are identical with those of enargite; it decrepitates in the closed tube and gives sublimates of sulphur and arsenic sulphide; with nitric acid and ammonia it gives the deep-blue solution indicating copper. Its appearance and reactions agree with those described for the mineral luzonite.

It seems rather remarkable that none of the four analyses above quoted show any traces of antimony, as between the arsenical and antimoniacal sulpho-salts of copper there is a constant variation and transition, and rarely, if ever, is one known without the other. Santos gives 5.12 per cent of antimony, and it seems highly probable that this better represents the composition of the ore. The analyses, however, are quoted as reported.[2]

Of superficial decomposition products there is in this region but little trace; occasional bunches of iron and copper carbonates and sulphates are found, but only in limited quantities. The geology of the region, as will be shown later, precludes any oxidized croppings of any but occasional veinlets, and, except for scattered points and sections of the

[1] Courtesy of Prof. Joseph Barrell, Yale University. This analysis confirms that previously made by H. M. Ickis, of the Mining Bureau.

[2] A second examination of Nos. III and V, for the presence of antimony, gave 0.11 per cent and 0.06 per cent metallic antimony, respectively, a "trace" in Nos. I and IV.

underground workings of the old Mancayan mine, decomposition products are singularly lacking.

DISTRIBUTION AND RELATIONS OF VEINS.

Of the ore deposits in the Lepanto area, and in fact in northern Luzon, that of Mancayan has been most known and is most prominent. The occurrence there of copper ore has led to further search in the vicinity, and while the Mancayan deposit is at present far beyond any other locality in size and value, the future may develop more extended masses of ore here or in other localities.

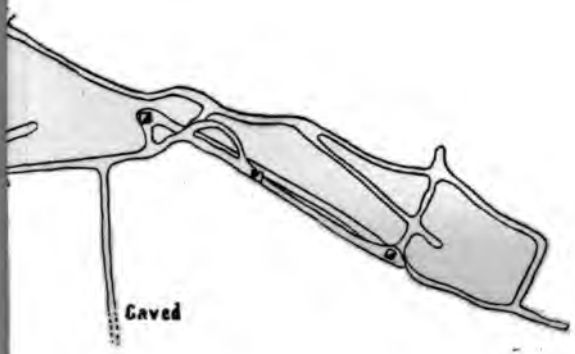
The Mancayan deposit has been uncovered for a long time by the Mangambang (Igorot, meaning "copper") River cutting a deep gorge diagonally across the southeast end of a quartzose mass bearing copper ores. At this place there is a nearly vertical wall of 100 or 200 feet, the strike of which, coinciding approximately with the course of the river, is northwest. From mining operations of past years there is a heavy talus and dump pile, and the face of the cliff is pierced by numerous tunnels, some of them mere dog holes, others cut with precision and good workmanship. Several systems of levels explore most of the ore body, the lowest one serving for the purpose of drainage. In the many years of operation of this mine several thousand feet of workings have been made and a considerable amount of ore extracted.

There is no indication of a regular form to the deposit, except that from a tunnel on the west side of the northern extension of the main deposit it is seen that the quartzose mass evidently dips 10° to 15° to the east, resting on the Mancayan diorite.

Much of the mine was flooded at the time of the visit, and without maps of the workings other than the one included in the report which was made of some of the principal galleries, it is only possible to draw general inferences as to the nature of the deposit.

The siliceous mass constituting the outcrop is apparently the same in character as the quartz porphyry described under "Rocks." At the Mancayan mine it loses its lithoidal nature and consists more or less entirely of quartz and ore minerals. The quartz has been previously shattered and jointed in every direction, and the cracks filled with either secondary quartz or ore minerals, notably pyrite, marcasite, chalcopyrite, and enargite. The mass at present is hard, compact, and firm, woven through with irregular veins of ore, with no system of distribution. The fissures, broadly speaking, have west-northwesterly and northeasterly directions, and of these the ones striking west-northwest seem to be most prominent as ore carriers.

The fissures would suggest contraction types due to cooling of an igneous effusion, dehydration of a mass, or some similar phenomenon, rather than those produced by dynamic causes. The fracturing has no



M. B. T.

other pronounced direction than that noted, and even this appears more or less forced.

This fracturing seems not to be confined entirely to the ore body, but is a characteristic of much of the surrounding rock mass. There is apparently no profound fissuring or faulting in the locality, and as yet no evidence is available that other displacement than the local fractures of the Mancayan ore deposit exist.

The "veins" formed by the recementation of the quartzose mass by silica and metallic sulphides vary from finger-breadth cracks to one body (the largest opened) over 20 feet across, of lens shape, of limited depth and length. There is no continuity of these singly, and the workings therefore follow the Spanish method and are crooked and narrow, following rich seams.

Unfortunately for a thorough investigation, many of the galleries were flooded or caved, and the exact relation of the deposit could not be made out. One important observation is worth recording: The lowest tunnel, a regular and large gallery, driven for drainage, has in its present length, and in the side drifts, which are under the greater part of the other workings, no signs of ore—in decided contrast to the rich values of a few feet above; the explanation of this is not certain.

From the nature of the ore masses, it is evident that the enargite and chalcopyrite and some quartz have been formed around the earlier particles of pyrite and quartz. The enargite is well crystallized and undoubtedly later than the pyrite, inclosing the latter.

From the few assays made it would seem to be indicated that the values in gold come from the pyrite, as the assay of a bowlder of almost pure enargite from the mine gives but little value, those samples of which a portion was pyrite showing values up to $5 a ton in addition to their copper content.

In the immediate vicinity of Mancayan there are but few openings of any depth or length, and only negative results are obtained from these. The western slope of the hill is predominantly an outcrop of the quartz porphyry, copper bearing to a mile north of Mancayan mine in variable amounts, and so far as shown decreasing in content to the north. No shafts deeper than a few feet have been sunk over the deposit, or in its vicinity, and these reveal only the soft material derived from the weathering of the trachyte. The tunnels on the east slope of the hill are driven in Mancayan diorite, and when the party left the field were still in that material, so that, except from the Mancayan mine proper, nothing is known of the extent of the deposit.

On the north slopes of Mancayan hill crop two exposures of the same vein, a 2-foot fissure of quartz, heavily loaded with pyrite and some chalcopyrite, the strike of which is east and west. No exploration has been made of this.

South of Mancayan, just west of Tuboc, conditions similar to those of the Mancayan outcrops prevail. There is there a standing face, 150 feet in height, of the same quartzose mass, but the rich ore seems entirely lacking, and the tunnels driven into it to the west so far have not shown other than promising indications.

At Cayan large slides and workings indicate that formerly values were sought, and the quartz-mass outcrops are of a slightly different character. The rock is more cellular in structure and is impregnated with pyrite only. Gold values obtain, and it is stated by reliable authority that these ores were mixed with the Mancayan ores in the blast furnace, on account of their siliceous and pyritiferous character. As the ground is well covered with Spanish pertenencias, no prospecting work has been done of late years.

The ores of the district alter perceptibly as more southerly points are reached, and in addition to the change noted at Cayan, Suyoc and its surrounding territory offer a decided contrast to the Mancayan type.

North of Suyoc, between it and Cayan, the ore-bearing veins are well-defined quartz leads, of small width, generally not over 3 feet, with a content of lead, zinc, and iron sulphides. No general direction of these veins can be traced, but it is the opinion of several of the miners in the district that those corresponding more closely to an east and west strike give the greater values. The length of the veins is limited and no depth beyond a few feet has yet been explored. The "country rock" is here the Mancayan diorite, much decomposed and altered, and the presence of veins of gypsum up to widths of several feet is noteworthy. Several acres of this territory have been cut down rapidly by the combined efforts of the rainy season and the Igorots in their workings, and an enormous slide results, the material being washed down the narrow gorge to join the Maanse River. Every rainy season the Igorots impound this water at the end of long ditches, "boom" away the overlying muck, and obtain a considerable amount of free gold by crushing and panning the vein material. It may be noted in this connection that an assay of the material the Igorot discarded as of no value yielded 0.20 ounce of gold per ton, a value of $4.03. Numerous pockets have been found in this slide that were surprisingly rich, it being stated that 20 *pounds* of metal was taken from one such occurrence a few years ago.

The Suyoc hill deposits, as yet only partially prospected, have the same general character—quartz veins of no great width, carrying metallic sulphides, and a considerable gold content, most of it in a free state. In two notable instances, on the "Eureka" claim of Mr. C. A. Pettit and the "Quien Sabe" of Mr. Albert Wright, copper sulphides form a great proportion of the vein filling, and these and the other properties are being developed by tunnels.

All along Suyoc hill, west and south of the Abra River, are large eroded

Photo by A. J. Eveland.

MANCAYAN COPPER MINE, SOUTHERLY ASPECT.

Photo by A. J. Eveland.

COPPER MINES, MANCAYAN.

Photo by A. J. Eveland.

COPPER MINES, MANCAYAN.

cirques, owing their existence primarily to ancient workings, and all of the same general type.

In view of the fact that the entire region, with the exception of the one ore body of the Mancayan mine, is in an early stage of development, it is impracticable to treat the ore deposits in detail. It seems to be fairly conclusive, however, that the general type of vein in the district is a narrow quartz lead, carrying metallic sulphides, in some cases of copper, and generally with gold associated in a free state. These veins are in the Mancayan diorite which underlies the entire district. With the advent of the trachyte flow, metamorphic changes have taken place, and the nature of the country rock altered to a considerable degree.

It would be rash to enter into a discussion of the genesis of the deposits on the meager data available, and in consequence such will be left to more complete reports that will follow detailed geological work upon a topographic base.

The former attempts to explain the Mancayan deposit have been given and objections to each have been found, and as a mere tentative hypothesis may be suggested a genesis of these ores as yet not considered, that will be determined when further development work is done. It is entirely within the grounds of probability, and not in conflict with any geological evidence so far at hand, to presume that, before the advent of the trachyte flow, ore deposits had been formed in the Mancayan diorite of a type similar to those at Suyoc—quartz veins carrying metallic sulphides and gold values. With the covering of the diorite and its veins by an igneous flow, chemical action was given an added impetus. The trachyte, easily decomposed and altered, was metamorphosed at its contact with the diorite to a hard, flinty, siliceous quartz porphyry, quartz replacing most of the other constituents of the rock. In its cooling and subsequent contraction fissures and crevices were formed, aided possibly by dynamic action, such as shattering shocks, which are a feature of the Islands. The heat of the overlying trachyte furnished a motive power for the process of vein deposition, and the heated waters, assumed to be rising, filled the cavities and cracks with silica and ore minerals obtained from lower or surrounding sources. Enargite is a prominent mineral among those formed by secondary action, and investigation shows that it has been formed later than the other minerals; so that the evidence points to a secondary enrichment of certain portions of the contact, notably at Mancayan, with copper minerals obtained from other sources. Deposition has taken place in all possible directions, leaving the irregular mass of veins of the Mancayan mine.

There is nothing in this hypothesis to preclude the possibility of other similar deposits in other portions of the area, or, indeed, of one or more veins, as yet not opened, in a more or less vertical position, which may occur under the trachyte, in the diorite, and which afforded a main trunk

channel for the ore-depositing solutions. Where erosion has been sufficiently deep to cut down near the diorite, such deposits may be revealed, but it is obviously useless to prospect in the trachyte surface, which is easily recognized by its granularity, color, and weathering to a characteristic clayey soil. Deep shafts *through* the trachyte, or proper crosscuts, at a depth easily to be obtained, will afford the only solution of the future of this district, and it is to be hoped that the efforts of those at work will be carried on to completion.

CHAPTER VII.

SUMMARY.

For a mining district which has been under exploitation for four or five years, the Mancayan-Suyoc area has surprisingly little development. Much of this lack of progress is due to natural conditions which prevail, but to some extent at least there is or has been a lack of initiative to put forth real effort. Assessment work has been done *as* assessment work, in disconnected pits and tunnels in the softest material that could be found, instead of combining each year's labor with that of the preceding to attain needed information. The net result is that the area presents an unsatisfactory aspect to the engineer who wishes to ascertain facts. Natural conditions in the Philippine Islands are invariably arrayed against the miner, the engineer, and the geologist; and when such conditions have to be faced, and in addition there is a dearth of developed information, but little may be had to aid the judgment. It does by no means follow that a fine showing of a prospect indicates a fine future, and conversely that a poor prospect is doomed to failure. Rarely does it occur that on an area so little developed as this enough data can be found to venture an authoritative opinion, and it is a fortunate state of affairs when condemnation or approval may be urged without reservation. While a natural allowance must be made for an enthusiastic spirit, there is still a great deal of truth in the current belief of the miners that this area "shows better surface indications" than any region of their experience. There is no doubt that, considered solely as "prospects," the greater proportion of the staked-out claims are well worth considering.

Of vital importance to the future prosperity of this region is the solution of several difficult problems. Provided more ore bodies of sufficient size and value are found, operators are faced with no small trouble of labor and transportation, with their directly depending questions of cost, profit, and treatment.

The labor problem in the Philippine Islands is one that up to date has not proven an insurmountable obstacle, but the location of this region adds a new phase to the problem which heretofore has not been considered. Throughout the Philippines as a whole it is the general consensus of opinion that Filipino labor can profitably be used when proper treatment and supervision are employed.

On the road work in a large proportion of the provinces Filipinos of various races have been employed, and with a single exception reports have been very satisfactory. Mr. N. M. Holmes, after three years of observation, as chief engineer of the Benguet road, condemns the Filipino laborer from every point of view. It is believed, however, that there were factors in that period which no longer have to be considered, as during the completion of the same enterprise, under the supervision of Maj. L. W. V. Kennon, United States Army, as chief engineer, reports as to the native labor employed were decidedly favorable.

The Atlantic, Gulf and Pacific Company, using up to 1,000 men, have, according to the report of Mr. H. Krusi, the vice-president, met with unqualified success. The Cavite Navy-Yard, also using large numbers of Filipino laborers, has, according to the report of Captain Couden, United States Navy, been equally successful in meeting the problem. The Manila Electric Railway and Lighting Company, in its construction and operation of about 60 kilometers of line, have used Filipinos from the start with like success. In all these works effort has been made to provide for the wants of the Filipino, to make life as comfortable as possible under the conditions, and to learn and apply the proper supervision.

Of more pertinence to this report is the unqualified statement of all at present engaged in mining operations that Filipino labor not only may be endured but that it bears comparison with other races. In Benguet, Masbate, Camarines, and other districts Filipinos are being used; in other districts native labor has been employed in the past; and all with goods results. The keynote seems to be successful and competent supervision, with as much careful study of native characteristics as would be given to any other little-known problem.

That the *proper* use of native labor reduces considerably the costs involved can not be denied, and this factor can not be neglected.

As has been stated previously, however, the problem in Lepanto has conditions peculiar to itself, which should be carefully considered. It may be said in the beginning that dependable labor, certain in supply and quality, can not be obtained locally. There is, it is true, a large population, most of them used to labor, to draw upon for limited or occasional demands, but that local supply will meet the demand of extensive mining operations, steadily and with the requisite intelligence, seems extremely doubtful, at least. This applies to the regular forms of more or less skilled labor which mining operations depend upon for their very existence.

Employment of white foremen and white skilled labor will be found necessary. The employment of Chinese and Japanese has met with a certain measure of success in other parts of the Islands, and the recent importations of East Indians, Tartars, and other races into South Africa to relieve labor troubles there is suggestive of possibilities.

Transportation at present, with but slight exception in the way of native porters or "cargadores," may be marked nil. Transport in both directions, supplies in and product out, must be considered. The present lines of travel are horse and foot trails, and the distance to the coast (about 40 miles) makes packing excessively expensive. Direct railroad projects seem unfeasible, and a railroad down the Abra Valley, with its terminus at Vigan, has been considered as questionable. The nearest light in that direction would seem to be an examination of the route between Lepanto and the capital of Benguet Province to the south, Baguio. There has been completed a superb wagon road from the northern terminus of the railroad, Dagupan, to Baguio, and the railroad continuation, probably under electric motive power, is assured within a short time. Mancayan and Baguio are about on the same level at an altitude of 5,000 feet, and the existence of a route along the mountain ridge between the two is very probable. It is expected that the present field work of the Bureau will throw light on this suggestion, and at all events the question of routes and costs can not be abandoned so lightly. It will take careful examination of known routes, and equally careful search over newer routes, before assurance may be had as to either result. It is not believed, however, that the difficulty is insurmountable.

The solution of these two most important problems, will practically eliminate the remaining obstacles. There is in the district water in sufficient quantities for considerable power, and by transmission from a small distance the whole power of the Abra River may be utilized, in a combination of hydraulic and electric methods.

It is doubtful if steam could be furnished at the mines for any considerable amount of call upon it. Former smelting operations and lack of preservation have removed the timber from the whole valley of the Abra, and while it is believed that plenty of wood fuel is within a reasonable distance, it would take careful calculation before any design of power plants could be considered.

We have, then, the consideration of a district whose prospects certainly appear of a favorable nature. There are numerous obstacles to be overcome, but all, of them, it is believed, may be handled if the one vital problem, of the presence of the ore, is settled. Given the ore, large and valuable enough, and the remainder of the problem becomes one of adaptation and engineering.

The old Mancayan mine was, without doubt, an extraordinarily rich deposit and the quantity of ore still remaining is worthy of examination. The ore dump, of huge size, contains ore that was then discarded, but under new conditions represents in itself a small mine of fai[redacted]. The old smelter sites and slag dumps are rich with such materi[redacted] containing as high as 32 per cent of copper, and further un[redacted] work may reveal more ore bodies. So far as the work already d[redacted]

much may be hoped for the rest of the district—everything depends upon further exploration. In many cases mining properties may be condemned very quickly by an examination, but the Mancayan-Suyoc area is far from being one of these. While positive assurances of a future are lacking, no efforts should be spared, and no amount of skilled exploration neglected to ascertain more; the district is decidedly not to be classed as of little value, and within a short time, under the scheme of exploitation planned, an ore-producing district of considerable magnitude and richness may not be unlooked for.

PLATE XLII